KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI, GHANA

Free Space Optical Communication over the Ghanaian Turbulent Atmospheric Channel

By

Prince Anokye (BSc. Computer Engineering)

PG5903011

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Chapter 1

INTRODUCTION

1.1 Background of Free Space Optical Communication

The field of wireless communication has been extensively researched in order to exploit the advantages it has over wired networks such as mobility and flexibility. The demand for bandwidth on wireless communication systems today is increasing at an exponential rate. Many bandwidth demanding applications (multimedia) are being developed these days. Thus traditional voice communication is not the only requirement of wireless communication in today's network. The main challenge is to design more adaptive and scalable networks that can provide high data rates to support the increasing demand for bandwidth. In view of this, several wireless networks have been developed to address the demand for high information carrying capacity.

The amount of data that can be transmitted in any communication system is directly related to the bandwidth of the carrier which is directly related to the carrier frequency. Optical signals use a frequency range of 20THz - 375THz and could therefore guarantee very high data rates. Optical communication systems thus promise the highest possible information carrying capacity. The theoretical information carrying capacity of free space optical communication systems exceeds that of microwave systems. The information carrying capacity of microwave systems is the highest so far amongst the available wireless networks.

Free Space Optical (FSO) communication is the transmission of high speed data over long distances using optical signals through free space. Free Space Optical (FSO) communication can be considered as a viable technology for next generation communication due to its wide range of applications [1, 2]. Some of its applications are links involving satellites (inter-satellite communication), High Altitude Platforms (HAPs), Unmanned Aerial Vehicles

(UAVs), terrestrial communications, aircraft and ship-to-ship communication. FSO can be used to provide high data rates in areas where it is difficult or impossible to lay optical fiber cables. Again, it can be used in both military and civilian applications [3]. It can be used to provide temporal links in the event of disaster.

FSO has more advantages over other traditional wireless technologies (i.e. Microwave systems). First, FSO can provide higher data rates (several gigabytes of data) than that provided by microwave systems. Secondly, it does not require licensing for its operation. This is a major cost advantage over microwave links. Again, FSO channels are highly immune to electromagnetic interference (EMI) and highly secure with low probability of interception and low probability of detection (LPI/LPD) properties [4].

However, FSO has some disadvantages which have hampered its wide deployment. It has low availability probability due to its susceptibility to atmospheric weather conditions [5]. The availability probability of a communication system is the percentage of time during which the communication link is operational. The availability probability requirement of wireless communication systems is 99.999% [6].

The primary atmospheric processes that affect optical signal propagation are atmospheric absorption, atmospheric scattering and index-of-refractive turbulence (Scintillation). For an optical radiation traversing the atmosphere, absorption occurs when some of the photons are extinguished by molecular constituents of the atmosphere and their energy converted into heat energy leading to loss of optical power. Again optical radiation through the atmosphere is attenuated by scattering caused by gas molecules and aerosols such as fog/haze, rainfall, snow etc. Scattering causes changes in the direction of propagation of the optical wave. The beam spreads out while traversing the atmospheric channel causing the size of the received beam to be wider than the receiver aperture. This leads to significant loss of optical power. Fog causes the most detrimental effects with attenuation measurements of 480dB/km reported in [7]. The concentration and distribution of molecular constituents of the atmosphere and aerosols depend on the geographical area and the season. The successful implementation of FSO communication therefore depends largely on the weather patterns of the area of installation. Detailed knowledge of the level of attenuation introduced by the local weather is therefore required before installation. Long optical links through the atmosphere suffer from strong fading as a result of index-of-refraction turbulence (scintillation) [8]. The temperature inhomogeneity of the atmosphere causes corresponding changes in the refractive index of the atmosphere [9]. Consequently, the optical wave travelling along the turbulent atmosphere with changing refractive index experiences fast fluctuations in its intensity and phase [9]. The transmitted optical power is reduced along the propagation path. The necessary margin to compensate for such loss is therefore required.

Again, FSO Communication requires very accurate Pointing, Acquisition and Tracking (PAT) techniques. This is due to its narrow unguided beam propagation through free space. It requires tightly clear line-of-sight (LOS) transmission.

1.2 Research Motivation

The ever increasing bandwidth requirement of present and emerging communication systems in Ghana is the main driving force behind this research. The use of smart phones is on the ascendency and the bandwidth demand on today's networks is so high. Several applications which require significant bandwidth are being run on these smart phones, laptops and tablet PCs. Traditional microwave communication systems can no longer support this high bandwidth demand. Telecommunications companies in the country are therefore investing huge sums of money in laying underground fiber cables for their backbone network. The challenges these companies face in laying optical fiber cables include inaccessibility in the major cities. These cities have already developed infrastructure (i.e. buildings and roads). Therefore digging and laying cables are very difficult if not impossible in some suburbs. In such areas, the companies are forced to depend on microwave links. Again, due to lack of already developed network infrastructure design in the country, underground fiber cables are destroyed during road constructions. An alternative to fiber cables in inaccessible areas could be the use of FSO installation. FSO can be used to provide backup links in the event of fiber cable destruction or as a backbone network.

To the best of our knowledge, evaluation of FSO performance in the country has not been investigated to determine its feasibility. No work has been done in the country to ascertain whether the Ghanaian weather patterns will tolerate FSO communication. This thesis seeks to investigate whether FSO communication implementation is feasible in Ghana.

1.3 Problem Statement

Free Space Optical Communication has the potential to provide high data rates, secured and license-free transmission but it is highly susceptible to Atmospheric conditions. This thesis seeks to investigate the effects of the Ghanaian atmospheric channel on FSO Systems to determine its feasibility in Ghana.

1.4 General Objective

The main objective of this thesis is to determine the feasibility of Free Space Optical Communication in Ghana.

1.4.1 Specific Objectives

The specific objectives of this research are:

1. To characterize the optical attenuation of Free Space Optical Communication Systems in Ghana based on the weather patterns.
    a. To estimate atmospheric attenuation of FSO Communication systems in Ghana
    b. To investigate the probability of encountering different atmospheric attenuation conditions.
2. To investigate attenuation caused by scintillation effects in Free Space Optics using statistical model.
3. To perform link budget analysis and investigate the availability of Free Space Optical Communication Systems in Ghana.

1.5 Organization of Thesis

The rest of the thesis is organized as follows: Chapter 2 presents a review of existing literature on Free Space Optical Communication. Chapter 3 introduces and discusses the various models employed in this thesis. Chapter 4 discusses the results of the research. The thesis is then concluded in chapter 5.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview of FSO communication and a review of related work done in the area of FSO communication. The challenges FSO communication faces are discussed. Key features and areas where FSO finds application are introduced. The chapter ends with a discussion on the basic architecture of FSO communication.

2.2 Overview of FSO Communication

FSO communication is the transmission of information/data over long distances using modulated optical signals through free space (or an unguided media). The unguided media could be space, water, atmosphere or a combination of any of these media. Since this research is about terrestrial transmissions, the medium of interest is the atmosphere. The data to be transmitted can be modulated in its intensity, phase or frequency of the optical signal. An FSO link is a line-of-sight (LOS) technology. It therefore requires the transmitter and the receiver to point directly to each other without any form of obstruction on their path. A typical implementation of FSO is a point-to-point communication with two similar transceivers at each end of the link as shown in fig 2.1. This arrangement allows data to be transmitted simultaneously between the two transceivers.

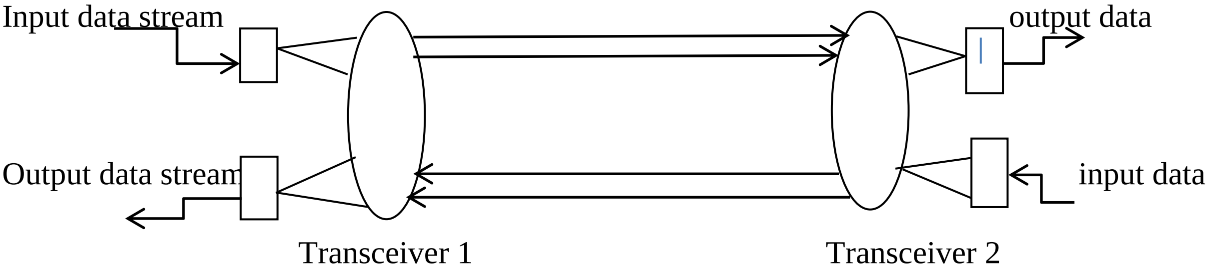

Fig 2.1 Typical FSO Setup

2.3 Review of Existing Related Work

In the face of all the challenges facing FSO Communication, several strategies have been proposed to mitigate the effects of atmospheric conditions such as diversity techniques [1,10,11,12,13], hybrid FSO/RF techniques [14,15,16], error-control coding [17] and autonomous mechanisms [1,18,19]. In this section, we will review some existing related research works.

In [4], Fang Liu investigates efficient algorithms to set up initial connected optical wireless network in the physical layer for PAT purposes. The network is abstracted by a graph where each node represents a base station and each edge represents a link connecting two base stations. Each node is equipped to send and receive signaling beacons within the given distance with which it has a line-of-sight for tracking purpose. Here a fully distributed approximation algorithm which constructs a spanning tree with maximal node degree than that in the optimal solution is developed. This algorithm is shown to outperform serial algorithms in terms of the actual-time performance. The algorithm developed here is only optimized to ensure fast connectivity. Other important metrics such as cost of potential links or the average end-to-end traffic in the network are not optimized.

In [12], Xiaoming Zhu and JM Kahn introduced both spatial-domain and temporal-domain techniques to mitigate the effect of turbulence-induced fading. Intensity modulation direct detection (IM/DD) under lognormal turbulent channel model is used. The marginal fading distribution and the joint temporal fading distribution are derived. In the temporal-domain technique, a single receiver is employed. If the receiver has knowledge of the marginal fading distribution but has no knowledge of the instantaneous fading state and the temporal fading correlation, a maximum-likelihood (ML) symbol-by-symbol detection can be employed [12]. If the receiver further knows the joint temporal fading distribution but not the instantaneous fading, maximum-likelihood sequence detection (MLSD) is used. In the spatial-domain technique, two receivers are employed to collect the optical signal from different positions or spatial angles. To maximize the diversity gain, the two receivers must be placed far apart so that fading at the receivers are uncorrelated but this is not always practical. Spatial diversity with optimal maximum-likelihood detection scheme is used. It concluded that the maximum-likelihood detection outperforms the Equal Gain Combining scheme. The drawback of this paper is that IM/DD is analyzed only under weak turbulence and requires that the distance between the two receivers must be greater than the correlation length of fading which is very difficult to achieve. Again, the MLSD requires multidimensional integration making it computationally complex which is excessive for most applications.

Navidpour in [13], used spatial diversity scheme to mitigate the effect of turbulence-induced fading. OOK under lognormal turbulence channel is assumed. To improve the error rate performance, multiple transmitters/receivers is used over the FSO link. BER expression is derived with multiple transmitters/receivers considering both spatially independent and correlated channels. A BER of 10^{-7} is achieved. However a BER of only 10^{-5} is achieved if the receiver knows only the Channel State Information (CSI). The drawback of this paper is that the received signal loss is severe if the correlation among multiple transmitters/receivers increases. The system therefore requires enough separation between transmitters/receivers apertures and exacting co-alignment. Both conditions are difficult to achieve.

AbdulHussein *et al* in [16], proposes the application of rateless coded automatic repeat request scheme for hybrid FSO/RF systems. The pertinent theoretic capacity limits for hybrid FSO/RF transmission is established. A simulation result for transmission with off-the-shelf Raptor codes is shown. The simulation results show realized transmission rates close to the established theoretic limits of hybrid FSO/RF systems under a wide range of channel conditions. The authors further show that rateless coding is more advantageous over fixed rate coding under strong turbulent conditions. The proposed system fully utilizes the available FSO and RF channel resources regardless of the FSO or RF channel conditions and temporal variations; there is no need for a-priori rate selection at the transmitter. The drawback of the proposed system is the parallel transmission of data on both the RF and FSO channels which compromises the security benefits of FSO transmission.

In [17], X. Zhu and JM Kahn showed that error-control codes can help mitigate turbulence-induced fading and thus increasing system performance. Intensity Modulation Direct Detection scheme through lognormal channel is assumed. An approximate upper bound on the pairwise code word error probability for transmission through correlated turbulence-induced fading is derived under the assumption of weak turbulence. This approximate upper bound is then applied to derive an upper bound on the bit-error probability for convolutional codes, block codes and turbo codes through weak turbulence. The approximate upper bound expression is given as:

$$P_{block} \leq \sum_{j, Cj \in Sc} P(Cj) \left[\sum_{k, Ck \in Sc} Pe(Cj, Ck)\right]$$

Where S_c is the set of all code words, *P(Cj)* is the probability that the code word *Cj* is transmitted, *Pe(Cj,Ck)* is the probability that when code word *Cj* is transmitted, the decoder favors the selection of incorrect code word *Ck.* The drawback of this work is the assumption of weak turbulence. The pairwise error probability is invalid under strong turbulence.

Belmonte derived an exact BER of M-ary Phase Shift Keying (PSK) in [20] considering both phase and amplitude fluctuations. Phase fluctuation is characterized by Gaussian distribution and the amplitude fluctuation is characterized by lognormal distribution. The signal phase is recovered at the receiver. Two different regimes of turbulence depending on the diameter of the receiver aperture are considered. The authors deal particularly with QPSK using synchronous homodyne or heterodyne detection. The number of modes needed for compensation at the receiver is derived. If the normalized aperture diameter is small, the impact of phase noise will be small and intensity fluctuations will become dominant. System performance is therefore greatly hampered. If the normalized aperture diameter is large, then the phase noise will be dominant. Hence a higher order mode for compensation is required.

In paper [21], Aniceto Belmonte and JM Kahn consider a coherent fiber array consisting of densely packed multiple sub-apertures in a hexagonal arrangement. Each sub-aperture is interfaced to a single-mode fiber optic cable for improvement in signal fading. The lognormal amplitude fluctuations, Gaussian phase fluctuations and local oscillator shot noise are considered. The authors have quantified the effects of amplitude fluctuations and wave front phase distortion on system performance and have identified different regimes of turbulence depending on the receiver aperture diameter normalized to the coherence diameter of the wave front phase. When the normalized aperture is large, amplitude fluctuations become negligible and phase fluctuations become dominant. It is shown numerically that such a coherent system using field conjugation adaptive arrays with multiple sub-apertures outperforms other coherent receivers employing single monolithic-aperture receivers. The drawback of this paper is that the phase fluctuations become dominant when the normalized aperture increases but in coherent systems the signal phase is also needed for information decoding.

In [22], Eric Wainright, Hazem H. Refai and James J. Sluss Jr investigated the use of wavelength diversity to alleviate effects caused by two fog conditions (radiation and advection fog) using MODTRAN simulation software. Information was encoded and transmitted on three carrier wavelengths, 850nm, 1550nm and 10000nm. The multiple carriers were combined and processed using Equal Gain Combining and Selective diversity techniques. Simulation results showed significant increase in the power received when Equal Gain Combining was used. However, 850nm and 1550nm wavelengths showed similar behavior when propagating through the same fog condition. Therefore it renders the system redundant when Selective diversity technique is used. Again, 10000nm wavelength laser equipment is not readily available for FSO system design.

Eric Korevaar, Isaac I. Kim and Bruce McArthur in [23], discuss the disconnection between perception and reality of FSO in both the market place and technical community. The authors develop a simple model used to estimate the outage/availability probability of FSO system. Visibility data from 10 cities in the US and 3 cities in the UK are used. Based on this model, the performance of four different FSO systems is compared. The model is as stated below:

$$\text{Outage Fraction} = 0.22 * A^{-1.18} * 100^{-(A/265)^{\wedge 10}}$$

where A is the specific attenuation. The authors also develop a simple formula to predict the necessary link margin to allocate to scintillation fading. The formula is as stated below:

$$\text{Margin (dB)} = 2 + (12/\text{ApNum}) * (100\text{mm}/\text{Diam})^{2} * (\text{Range}/1000\text{m})$$

Where ApNum is the number of transmitters, Diam is the diameter of the receiver telescope, Range is the propagation length. The system availability is shown to decrease with increase in the link range. It is further shown that the added performance to be gained by incorporating expensive tracking or adaptive optics technology may not generally justify the cost. The drawback of this paper is that the outage/availability model does not consider the wavelength dependence of the attenuation even in high visibility conditions. The asymptotic attenuation value which is average specific attenuation in three cities in the UK which is in a different geographical location (with different weather dynamics) can be very misleading and inaccurate when applied in tropical Africa. The link margin formula for scintillation does not take into account the signal wavelength and random nature of the refractive index profile along the propagation path. Again the number of transmitters used cannot necessarily reduce the scintillation fading if the signal fluctuation is correlated among the transmitters.

In [24], an experiment to measure the attenuation experienced in FSO systems during foggy events is conducted. An FSO link with a wavelength of 830nm operating on a 100 meter-long path and located at a height of 26meters above ground level is implemented in Prague, Czech Republic. The authors show a good relationship between received power levels and visibility. The power levels fall as the visibility drops and rises when visibility rises. The shifted power law model and inhomogeneous model [25] is shown to perform better for low and medium visibilities.

V. Sharma and G. Kaur in paper [26], review internal and external factors that degrade the performance of FSO links. Techniques to alleviate some of these challenges are also suggested. The authors mention some of the degrading factors as scintillation, absorption and scattering from fog, rain drops and atmospheric molecules. The received power level and the amount of attenuation are shown to be dependent on the atmospheric visibility, operating wavelength, link length and the transmitted power. It is suggested here that spatial diversity techniques employing multiple transmitters and receivers can help mitigate degrading effects of scintillation. Boosting the transmitted power is also suggested to deal with scattering by fog. Hybrid RF/FSO techniques can also mitigate signal degradation from fog and rain drops. The drawback of this paper is that, the authors did not show how the suggested approaches can indeed mitigate the degrading factors.

Paper [27] discusses the propagation of light through fog with an atmospheric propagation model based on the radiative transfer equation. The light source is assumed to have an isotropic radiation pattern. The authors show that for thin fog, image blooming loss is more dominant than attenuation loss and therefore image blooming loss needs to be considered when designing FSO systems. The main drawback of this paper is the assumption of isotropic radiation pattern of the light source. Transmitters used in FSO systems do not have isotropic radiation patterns. FSO systems typically employ highly directional laser sources which require strict alignment; the model will therefore be invalid when applied to such systems.

In [28], the authors investigate the possibility of simplifying the Monte-Carlo Ray Tracing (MCRT) algorithm in analyzing the channel behavior of wireless optical communication systems. A direct extraction of the state transition matrices associated with standard Markov Chain model is used. It is shown that by tracing a photon's trajectory in space via a Markov Chain model, the angular distribution of the photon can be calculated by a simple matrix multiplication. The computational complexity of this Markov Chain model is shown to be far less than the MCRT algorithm though it performs similar to the MCRT algorithm. The computational time for the Markov Chain model remains constant with increase in the optical thickness but the MCRT algorithm's computational time increases as the optical thickness increases. However, this model is still numerically intensive and more computationally complex than the moment generating techniques.

It should however be pointed out that more effective strategies to deal with atmospheric attenuations and PAT problems are still actively under research. Much work has been done as far as atmospheric turbulence is concerned. Effective PAT techniques still continues to be a major challenge. Attenuation due to fog still needs further investigation due to the complexity and persistence of fog in the atmosphere depending on the geographical location. FSO system design and implementation therefore requires careful study of the local atmospheric conditions of the area of installation.

2.4 Challenges of FSO

Free Space Optical (FSO) communication promises a very bright future in terms of its high data rate, immunity to electromagnetic interference (EMI) and security. Despite these advantages, some challenges have inhibited its widespread deployment. In this section, we will introduce some of the challenges that FSO communication faces.

2.4.1 Atmospheric effects

The propagation channel of every communication technology has some effects on the signal transmission. The propagation channel of FSO is the atmosphere and the FSO links' reliability is usually dependent on the local weather patterns. Optical scattering, optical absorption and Index-of-Refractive Turbulence (IRT) are the primary atmospheric processes that influence optical signal propagation. The main challenges of optical communication through the atmosphere are attenuation of optical power and fluctuations of received optical signals [3]. Our viewing of distant objects are affected by atmospheric conditions such as clouds, haze, fog, rain, smoke and dust particles. Optical wave propagation through the atmosphere is affected by these same atmospheric conditions. Optical signals are attenuated by the absorption, scattering and refraction of optical waves by gas molecules and aerosols such as rain, fog, haze and snow. Fog is the most detrimental attenuating factor with measurements of attenuation of 480dB/km under dense fog reported in [7]. Successful implementation of FSO therefore requires detailed knowledge of the weather patterns of the area of installation. The area of installation must be investigated to ascertain the level of attenuation caused by the local weather patterns. Optical signals are still attenuated under clear-sky weather conditions by fluctuations in the refractive index of the transmission medium. These cause fast fluctuations (scintillation) of the optical signal at the receiver end. The necessary margin must therefore be included in the link budget to compensate for such losses.

2.4.2 Pointing, Acquisition and Tracking (PAT)

PAT schemes have been a serious challenge facing FSO. Typical FSO links require a clear LOS between transmitter and receiver. Transmitters send out optical beams with narrow beam widths and divergence of few *mrads* and receivers have small angle field of view. This property associated with FSO has made FSO links immune to electromagnetic interference (EMI) and secure with low probability of interference/low probability of detection (LPI/LPD) properties [4]. These same properties on the other hand have made it very difficult to establish connection between two transceivers. To maintain connectivity between two transceivers, both must point at each other directly with very accurate LOS direction during transmission.

The *pointing* mechanism begins with finding out where potential nodes exist for establishing a link in free space and then proceeds to the connection procedure [5]. Since there may be many connection options available when multiple nodes are within range of each other, FSO nodes need to coordinate themselves with respect to which node to point to [5]. It is non-trivial to establish an initial connection between two transceivers even for stationary nodes due to the narrow beam width.

The *acquisition* mechanism involves modulation and signal detection techniques. The receiver aperture can intercept many potential optical beams and has to resolve which one is required and decode it accordingly. Again, in the aspect of physical aperture, the aperture diameter needs to be adjusted according to the divergence of the emitted laser beam and the distance in order to maximize the efficiency of the power budget [5].

The *tracking* mechanism must also be considered even for stationary links. This is also induced by the narrow beam width. Since FSO is a clear LOS technology and requires a very high pointing accuracy, signal tracking must be considered even in stationary transceivers and remains a challenging factor. Transceivers can be blown out of alignment by strong winds. Misalignment effects can reduce the capacity and increase the outage probability of the FSO link and therefore the signal needs to be tracked to maintain a perfect alignment.

In spite of all these challenges, recent research has shown that FSO is feasible when the weather conditions are favorable. Researchers have focused on the physical layer to fully take advantage of the potential of FSO. Several strategies have been proposed to deal with the low availability issues associated with FSO communication such as hybrid FSO/RF [14, 15], diversity techniques [6, 10, 11], autonomous mechanisms [4, 18, 19] etc.

2.5 Features of FSO

The basic features of FSO technology are stated below:

i. **High Data Rates (Bandwidth):** The amount of data that can be transmitted in any communication system is directly related to the bandwidth of the carrier which is directly related to the carrier frequency. The allowable data bandwidth can be up to 20% of the carrier frequency. Optical signals use a frequency range of 20THz - 375THz and could therefore guarantee very high data rates. This is because on the electromagnetic spectrum, the optical carrier frequency which includes visible, ultraviolet and infrared light are far higher than the radio frequency.

ii. **Narrow Beam width:** The beam width of optical signals is very narrow. Typical laser beams have diffraction limited divergence angle between 0.01 – 0.10mrad [6]. This means that the optical power is concentrated within a narrow area and therefore requires a line-of-sight (LOS) between transmitter and receiver. Optical signals are immune to electromagnetic interference and provide opportunity for unlimited frequency reuse because of this property.

iii. **Highly Secured*:*** Optical signals are highly secured with low probability of interception and low probability of detection (LPI/LPD) properties [4]. Laser beams generated by FSO systems are narrow and invisible. This makes them difficult to capture and even more difficult to crack. Optical beams cannot be detected with RF meters or spectrum analyzers [29].

iv. **Weather dependency:** FSO implementation highly depends on the weather patterns of the area of installation because atmospheric conditions like rainfall, fog, temperature, atmospheric turbulence, dust particles and smoke directly affect the availability and reliability of the FSO link.

v. **Unlicensed Spectrum:** RF signals face a major problem of interference as a result of congestion of the RF spectrum. Local regulatory authorities like National Communications Authority (NCA) in Ghana, Office of Communication (Ofcom) in the United Kingdom and Federal Communication Commission (FCC) in the United States regulate the use of the RF spectrum in their respective countries. To use any RF requires license from the local authorities which cost a lot of money. The use of the electromagnetic spectrum for FSO does not require any form of licensing from local authorities and therefore is a major cost advantage over the use of RF.

vi. **Ease of Deployment:** The time it takes for FSO link to become operational from its start of installation to its alignment is relatively short. The major requirement is to ensure clear LOS without any form of obstruction between the transmitter and receiver. This is unlike the use of fiber optic cables which requires right of way and trenching adding extra cost to the installation.

2.6 Application Scenarios of FSO

The characteristic features of FSO discussed above make it very attractive for various application scenarios. Again, FSO communication links can be employed in both military and civilian applications [3]. Below are some of the application scenarios of FSO:

i. **Deep Space Probes:** In deep space probes, the mass, power and volume of onboard equipment is severely restricted and hence the antenna diameter and transmit power are quite limited. According to [30], lasercom terminals for space probes have lower mass than RF systems. The mass reduction amounts to 0.65 and 0.55 for data volumes of 0.1 Gb/day and 10 Gb/day respectively. If a large aperture optical platform is available in a space station or a data relay satellite system, a small user terminal could be utilized in space probes. Such a platform would constitute an effective backbone communication station unaffected by visibility conditions of the ground stations [5].

ii. **Links involving Satellites:** Free Space optical links can be used in satellite communications to establish a global backbone network. This is because satellites can support any terrestrial location regardless of any topographical limitations as long as a line-of-sight (LOS) space path exits. Therefore optical links involving satellites can offer high quality service (Gigabits data) even to isolated areas such as an island, a rural area or an isolated country. FSO Links involving satellites includes inter-satellite links (ISL), satellite-to-air and satellite-to-ground. Inter-Satellite Links (ISLs) are designed for routing data traffic hop-by-hop through satellites toward a final destination satellite that has up-and-down links between aircraft or the surface of the earth. Normally, such links have very high data rates (>=10 Gbps). Thus ISLs can provide inter-continental communications.

iii. **Terrestrial Networks:** FSO can be used in terrestrial networks to establish a point-to-point and LOS optical connection between two transceivers through the atmosphere. The distance of light propagation through atmospheric space can be from hundreds of meters to a few tens of kilometers due to the LOS property. Since data rates of FSO are comparable to fiber optics (Gigabit data rate), this telecommunication paradigm can be an important means for broadband internet access. Some application scenarios that can be associated with FSO terrestrial networks are:

- **Last mile access:** FSO can be used to bridge the bandwidth gap (last mile bottleneck) that exists between end users and the fiber optic backbone.
- **Fiber Optic Back-up link:** FSO can be employed to provide backup for the optical fiber backbone against data loss or in the event of fiber optic cable destruction/breakdown.
- **Cellular communication back haul:** FSO can be used to provide a backhaul for traffic between base stations and switching centers in the 3rd/4th generation networks. It can be used as a backbone link in

inaccessible areas where fiber optic cables cannot be installed underground.

- **Temporary Links:** FSO can be used to establish a temporary link in the event of a disaster or collapse of existing communication network due to its ease of installation.

The figure 2.2 illustrates some of the application scenarios of FSO communication link.

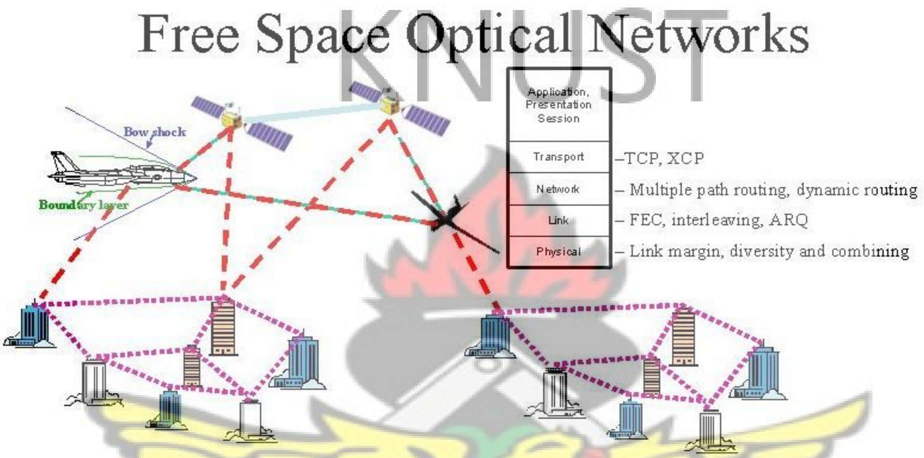

Figure 2.2 Application scenarios of Free Space Optics [31]

2.7 Block Diagram of FSO

The block diagram of a typical terrestrial FSO network is shown in figure 2.3. FSO system, like any other communication technology, is essentially composed of three main systems namely the transmitter, the communication channel and the receiver.

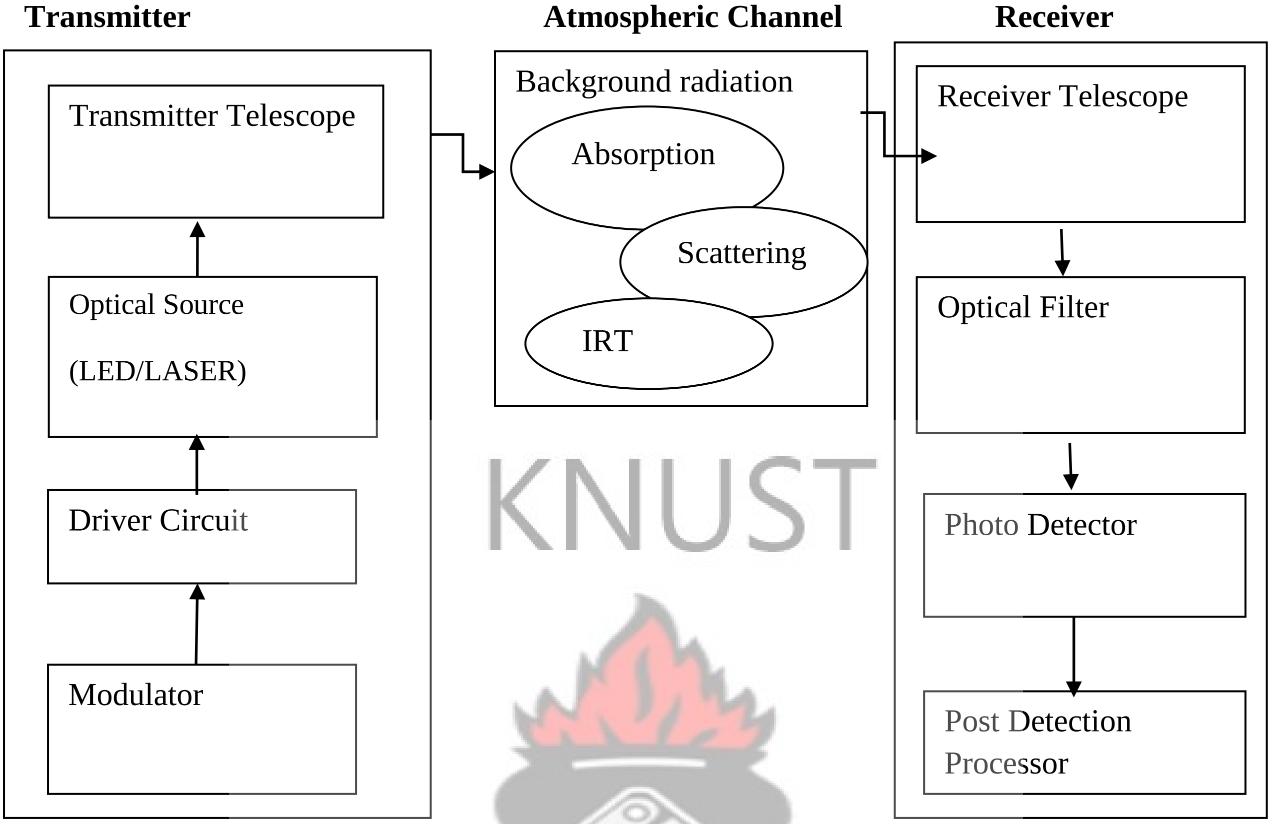

Figure 2.3 Block Diagram of FSO

2.7.1 The Transmitter

The transmitter has the primary task of modulating the source message onto the optical carrier for propagation through the atmosphere to the receiver end of the communication channel. The transmitter is made up of the modulator, driver circuit, optical source and the transmitter telescope.

The modulator is responsible for modulating the source message onto the optical carrier. On-Off-Keying (OOK) modulation scheme is the most common used in FSO communications. The source data is modulated onto the irradiance of the optical source. This is attained by changing the driving current of the optical source directly in sympathy with the data to be transmitted or via an external modulator, such as the symmetric Mach-Zehnder interferometer. Thus a logic "one" is transmitted by turning off the optical source whilst logic 'zero' is transmitted by turning off the optical source. This is called Non-Return-to-Zero

(NRZ) coding in its simplest form. Return-to-Zero (RZ) coding, a variant of NRZ, also exists. From [32], the RZ has more advantages over NRZ because in RZ, the clock signal lies within the modulation spectrum and has a higher sensitivity. However, clock synchronization loss can occur in both RZ and NRZ when there is transmission of long series of 0's or 1's. To avoid this phenomenon, Manchester encoding which is a variant of RZ can be employed. This coding scheme forces changes in state at the start or in the middle of clock cycles [32]. With this coding scheme, the digital clock can always be recovered. Again, 8B/0B-NRZ coding which is normally employed in optical fiber communications can also be employed in FSO communication systems. According to [3], 8B/0B-NRZ coding requires 25% more bandwidth than NRZ. This coding scheme forces frequent level changes irrespective of the data stream input. Thus if there is transmission of long series of 0's or 1's, the clock signal can never be lost.

On-Off-Keying modulation is very sensitive to distortions in signal amplitude. Atmospheric conditions such as clouds and fog can significantly affect its performance by attenuating the received signal. The exact wavelength and the phase of the optical carrier are however irrelevant for the demodulation of the received signal.

The optical signal can also be modulated in the phase, frequency and the polarization properties. For example, coherent modulation schemes such as Binary Phase Shift Keying (BPSK) and Differential Phase Shift Keying (DPSK) can be used in FSO systems. In BPSK modulation, the optical signal is shifted between two different states to transmit either a logic "zero" or logic "one". In Coherent receiver systems, the receiver relies on the superposition of the optical signal received with the light of a local oscillator. Optical phase-locked loop is employed in systems which use BPSK coding. This permits the local oscillator to be exactly tuned to the frequency and phase of the received optical carrier. Coherent modulation schemes are more sensitive than OOK. The disadvantages of coherent modulation schemes are higher system complexity and the fact that they are susceptible to distortions of the atmosphere.

Generally, intensity modulation schemes are more robust than coherent modulation schemes when considering atmospheric distortions. This is because in intensity modulation schemes, the information encoding is done only with the intensity of the signal whereas in coherent modulation schemes, both the signal intensity and the phase are used. It should be noted that distortions of atmosphere affect both the intensity and the phase of the optical carrier.

The transmitter telescope collects, collimates and directs the optical radiation from the optical source to the receiver at the other end of the channel. The optical source used in FSO systems can either be LED or laser. For low data rates (up to 10Mbps) and shorter distances LED can be used but for longer distances and high data rates (Gb/s of data), laser is the preferred choice. Table 2.1 lists some optical sources and associated wavelengths used in FSO systems.

Table 2.1 Optical Sources

Wavelength range (nm)	**Laser Type**	**Remarks**
780 - 850	Vertical Cavity Surface Emitting Diode (VCSED)	i. Inexpensive CD laser and readily available components. ii. High performance and reliable iii. Short life span iv. Sensitive receivers v. beam detection through the use of a night-vision scope

1300 - 1550	i. Fabry-Perot lasers ii. Distributed Feedback Lasers	i. Longer life span ii. Compatibility with wavelength division multiplexing (WDM) iii. Compatible with erbium-doped fiber amplifier technology (>500mW power) iv. More expensive components v. Less sensitive receivers
~10000	Quantum Cascade Laser	i. Relatively new ii. Better thin fog performance iii. Cannot penetrate glass iv. Components are not readily available
Near infrared	LED	i. Cheaper ii. Non coherent iii. Simpler driver circuit iv. Lower data rates

It is important to note that although the atmosphere is considered to be highly transparent in the visible and near infrared wavelength bands; certain wavelength bands can experience severe absorption. In the near infrared band absorption occurs primarily in response to water particles which are inherent components of the atmosphere even under clear atmosphere. There are several transmission windows that are nearly transparent (i.e. have attenuation of <2 dB/km [6]) within the 700 – 10000nm band. Majority of FSO systems are designed to operate in the 780 – 850 nm and 1520 – 1600 nm wavelength bands. The former is the most widely used because components are readily available and less expensive. The 1550nm is also attractive for a number of reasons. It is allowed to transmit more power than its 850nm counterpart for eye safety reasons (i.e. more power can be transmitted to overcome attenuation by aerosols), compatibility with wavelength division multiplexing (WDM) and reduced background solar radiation and scattering in light haze or fog [6]. However its disadvantages include reduced receiver sensitivity and higher component cost.

2.7.2 The Atmosphere

The atmosphere is the transmission channel for FSO. The propagation of optical signals through free space is affected by three main processes namely absorption, scattering and Index-of-Refractive Turbulence (IRT). The transmittance of optical radiation that travels over a distance L can be modeled by the Beer Lambert's law [3]:

$$T = \frac{Pr}{Pt} = exp\{-\alpha(\lambda) \cdot L[km]\}$$

Where *Pr* is the optical power received; *Pt* is the optical power transmitted; α is the extinction coefficient (km^{-1}) and L is the distance of propagation (km). The extinction coefficient describes the extinction level of the medium. The extinction coefficient has two components namely absorption and scattering.

For an optical radiation traversing the atmosphere absorption occurs when some of the photons are extinguished by molecular constituents of the atmosphere and their energy converted into heat energy. The table 2.2 lists the molecular constituents of the atmosphere.

Table 2.2 Molecular constituents of the atmosphere

Molecular constituent	Ratio (%)	Parts Per Million (ppm)
Nitrogen (N_2)	78.09	
Oxygen (O_2)	20.95	
Argon (Ar)	0.93	
Carbon dioxide (CO_2)	0.03	
Water vapor (H_2O)		40 - 40000
Neon (Ne)		20
Helium (He)		5.2
Methane (CH_4)		1.5
Krypton (Kr)		1.1
Hydrogen (H_2)		1
Carbon monoxide (CO)		0.2
Nitrous Oxide (N_2O)		0.6
Ozone (O_3)		0.05
Xenon (Xe)		0.09

Again optical radiation through the atmosphere is attenuated by scattering caused by gas molecules and aerosols like fog/haze, rainfall, snow etc. This can be modeled by the Rayleigh or Mie scattering coefficient. In general, attenuation due to scattering reduces with wavelength and altitude [3]. Scattering causes changes in the direction of propagation of the optical wave. The beam spreads out while traversing the channel causing the size of the received beam to be wider than the receiver aperture. The concentration and amounts of the aerosols depends on the geographical location and the season. Therefore the installation of FSO systems requires a detailed investigation to ascertain the level of attenuation caused by the local weather patterns of the area of installation. The most detrimental atmospheric factor is fog and can sometimes render the link useless.

Atmospheric turbulence is another feature that must be considered. Even under clear weather conditions, optical wave propagation is attenuated by atmospheric turbulence. When the earth is hit by the sun's radiation, the earth surface absorbs some of the radiation. This results in the heating up of the earth's surface air mass which rises up and mixes turbulently with the cooler surrounding air mass. The mixing up of warm and cooler air mass causes small but spatially and temporally fluctuating atmospheric temperature [9]. The temperature inhomogeneity of the atmosphere causes corresponding changes in the refractive index of the atmosphere which results in the formation of eddies (i.e. cells or air packets having varying sizes of ~0.1cm to ~10cm). These eddies act like refractive prisms with varying refractive indices. Therefore the propagating light wave is completely or partially deviated from its original trajectory. The deviation depends on the relative beam size and the degree of temperature inhomogeneity along its path [9]. Consequently, the optical wave travelling along the turbulent atmosphere experiences fast fluctuations in its intensity and phase. This phenomenon introduces losses in the transmitted optical source. The necessary margin is therefore required to compensate for such losses in the optical link budget.

2.7.3 The Receiver

The responsibility of the optical receiver is to recover the transmitted information from the incident optical wave. The optical receiver essentially comprises the receiver telescope, optical filter, photo detector and the post detection processor.

The incoming optical radiation is collected by the receiver telescope and focused onto the photo detector. Aperture averaging can be employed to reduce attenuations experienced as a result of beam spreading. In aperture averaging, the receiver telescope is made relatively larger so that it can collect multiple uncorrelated optical radiations, average them and focus their average onto the photo detector. It should however be noted that a wide aperture also increases the background radiation or noise as it collects other light sources of light like the solar radiation.

The optical filter is responsible for filtering the transmitted optical radiation from other sources of light like the sun impinging on the receiver aperture. This helps reduce the amount of background radiation.

The photo detector collects the incident optical radiation from the receiver telescope and converts it back into electrical signal. P-I-N diode or Avalanche Photodiode (APD) is employed to do the conversion. The table 2.3 below lists the commonly used photodiodes in laser communication and their characteristics [33].

Table 2.3 Types of photodiodes [33]

Material & structure	**Wavelength (nm)**	**Responsivity**	**Gain**	**Sensitivity**
Si P-I-N	300-1100	0.5	1	-34dBm @ 155Mbps
InGaAs P-I-N	1000-1700	0.9	1	-46dBm@ 155Mbps
Si APD	400-1000	77	150	-52dBm@ 155Mbps
InGaAs APD	1000-1700	9	10	-33dBm@ 1.25Gbps

The post detection processor or decision circuitry does the amplification, filtering and signal processing necessary to guarantee a highly reliable data recovery. The receiver detection process can be classified into two; namely, the direct detection receiver and the coherent detection receiver. The direct detection receiver detects the instantaneous optical power impinging on the photo detector. Hence the output of the photo detector is proportional to the incident optical wave. The coherent receiver works on the photo-mixing phenomenon. The incoming optical field is mixed with another locally generated optical field on the surface of the photo detector. The coherent receiver can be further divided into homodyne and heterodyne receivers. In homodyne receivers the frequency of the local (optical) oscillator is exactly the same as that of the incoming radiation whilst in heterodyne receivers the incoming radiation and the local radiation wavelengths are different.

2.8 Summary

In this chapter, we described the concept of Free Space Optical (FSO) Communication. We reviewed some existing related work done. Features, application scenarios and challenges of FSO technology have been discussed. The atmosphere poses serious challenges for FSO and therefore imperative to study the effect of the area of installation on the system. This thesis seeks to investigate the effects of the Ghanaian weather patterns on FSO communication systems. Again, the margin to compensate for losses due to scintillation effects will also be investigated. Availability of FSO communication systems in Ghana will be determined.

Chapter 3

METHODOLOGY

3.1 Introduction

This chapter presents the various models used in the thesis. These models include model for the transmission of optical signals through the atmosphere and model for the study of the effects of scintillation. The lognormal statistical model is used to study the effects of scintillation. Geometrical loss in FSO systems will be discussed. We will end the chapter with a discussion on the link budget analysis and availability of FSO communication systems.

3.2 Model of Transmission of Optical Signals through the Atmosphere

The transmission of optical signals through the atmosphere can be modeled by the Beer-Lamberts law. The Beer Lamberts law can be stated as [3]:

$$\tau(\lambda, L) = \frac{Pt(\lambda,0)}{\Pr(\lambda,L)} = \exp(-\gamma(\lambda)L) \quad \textbf{(1)}$$

where $\tau(\lambda, L)$: the transmittance of the atmosphere

$Pt(\lambda, 0)$: the emitted power from the transmitter

$\Pr(\lambda, L)$: the received power after a distance of propagation, L

$\gamma(\lambda)$: the atmospheric attenuation coefficient (km^{-1})

The value of the atmospheric attenuation coefficient is dependent on the optical wavelength, λ. $\gamma(\lambda)$ is composed of both atmospheric absorption and scattering terms and can be expressed as:

$$\gamma(\lambda) = \alpha_m(\lambda) + \alpha_a(\lambda) + \beta_m(\lambda) + \beta_a(\lambda) \quad \textbf{(2)}$$

Where $\alpha_m(\lambda)$: molecular absorption coefficient

$\alpha_a(\lambda)$: aerosol absorption coefficient

$\beta_m(\lambda)$: molecular scattering coefficient

$\beta_a(\lambda)$: aerosol scattering coefficient

Molecular absorption coefficient, $\alpha_m(\lambda)$ is a wavelength-selective phenomenon and can be avoided by the proper selection of the optical wavelength being used. Absorption by molecular constituents of the atmosphere (i.e. H_20, CO_2, N_2 etc.) defines the main atmospheric transmission windows used in FSO systems. The table 3.1 below shows the transmission windows used in FSO systems.

Table 3.1 Optical transmission windows

Electromagnetic Spectrum	**Wavelength Range (micrometer)**
Visible and very-near Infrared	0.4 to 1.4
Near Infrared	1.4 to 1.9 and 1.9 to 2.7
Mean Infrared	2.7 to 4.3 and 4.5 to 5.2
Far Infrared	8 to 14
Extreme Infrared	16 to 28

Therefore $\alpha_m(\lambda)$ can be neglected in the equation (2). The aerosol absorption coefficient, $\alpha_a(\lambda)$ describes the absorption of optical signals by aerosols such as fog, rain and haze. It is given by the exact Mie theory [34] as:

$$\alpha_a(\lambda) = 10^5 \int_0^\infty Qa(\frac{2\pi r}{\lambda}, n'')\, \pi r^2 \frac{dN(r)}{dr}\, dr \quad (\text{km}^{-1}) \qquad \textbf{(3)}$$

Where $\frac{dN(r)}{dr}$: particle size distribution per unit of volume (cm^{-1})

n" : imaginary part of the refractive index of the aerosol particle

r: radius of the aerosol particle

$Qa(\frac{2\pi r}{\lambda}, n'')$: Absorption cross section for a given aerosol

The imaginary part of the index of refraction is very minimal and negligible in the visible and near infrared spectral regions. Most FSO systems operate in this spectral region and therefore the aerosol absorption coefficient of the atmosphere can also be ignored in the equation (2).

The size of molecular constituents of the air are very small compared to visible and near infrared wavelengths used in FSO systems (i.e. 850nm and 1550nm). Therefore molecular scattering can also be ignored. The only dominant atmospheric factor that inhibits optical transmission is the aerosol scattering coefficient. Equation (2) therefore can be reduced and expressed as:

$$\gamma(\lambda) \cong \beta_a(\lambda) \quad \textbf{(4)}$$

Assuming the aerosol particles are spherical in shape, the exact Mie Scattering theory can be applied to calculate the scattering cross-section, Cs, of the aerosol particle when the radius, r, of the particle is known. Thus the theoretical value of the normalized scattering efficiency, Qs, can be estimated as [35]:

$$Qs = \frac{Cs}{\pi r^2} \quad \textbf{(5)}$$

$$\gamma(\lambda) \cong \beta_a(\lambda) = \int_0^{\infty} Qs(\frac{2\pi r}{\lambda}, n')\, \pi r^2\, N(r)\, dr \quad \textbf{(6)}$$

Where n': the real part of the index of refraction of the aerosol

$Qs\left(\frac{2\pi r}{\lambda}, n'\right)$: Scattering cross-section for a given type of aerosol

N(r): the particle size distribution

The modified gamma distribution as an analytical function can be used for modeling aerosol particle distribution. It is expressed by [36] as:

$$N(r) = ar^{\alpha} \exp(-br) \quad \textbf{(7)}$$

Where a, r and α are the parameters characterizing the particle size distribution.

The normalized scattering coefficient is mainly dependent on the size parameter which also depends on the wavelength of the incident optical wave and radius, r of the particle. The size parameter is the ratio of the aerosol particle size to the wavelength of incident light. Therefore the resultant attenuation coefficient will be highly dependent on the incident wavelength. The Mie scattering theory provides very accurate measurement of the atmospheric attenuation coefficient due to scattering by particles of various sizes. However the theory is more complex because of the complexity of the aerosols' physical properties. Some of the particles properties such as the refractive index and the particle radius required for computations may not be readily available.

The Kruse model [37] can be employed to estimate the scattering attenuation coefficient, $\beta_a(\lambda)$. The Kruse model relates the atmospheric attenuation coefficient to the meteorological visibility of the atmosphere and the optical wavelength, λ. Equation (4) can therefore be expressed as [37]:

$$\gamma(\lambda) \cong \beta_a(\lambda) = \frac{10\log(\frac{1}{th})}{V[km]} * \left(\frac{\lambda[nm]}{\lambda o[nm]}\right)^{-q} \quad (dB/km) \quad \textbf{(8)}$$

Where th: optical threshold (2% or 5%). 2% optical threshold is used in optical communication systems and 5% threshold is used in airports to measure the runway visual range

V: the visibility of the atmosphere in km

λo: wavelength corresponding to the maximum spectrum of the solar band (500nm)

q: parameter relating to the particle size distribution of the atmosphere

$$q = \begin{cases} 1.6 \; for V > 50km \\ 1.3 \; for 6km < V < 50km \\ 0.585V^{1/3} \; for V < 6km \end{cases} \quad \textbf{(9)}$$

Visibility, V[km] is the parameter that describes the atmosphere's transparency. It is defined as the distance to an object at which the image contrast reduces to a certain percentage of the original contrast of the object; equivalent to a certain threshold over the atmospheric path [38]. The transmission threshold can be 2% or 5%. The 2% threshold is employed in the original Kruse model with the 5% employed at airports to measure the Runway Visual Range (RVR). The visibility is technically measured at the center of the sensitivity of the human eye at 550nm wavelength with a spectral bandwidth of 250nm. The atmospheric visibility can characterize every atmospheric condition like rainfall, haze and fog. The table 3.2 below gives the visibility range values for different atmospheric conditions [34].

Table 3.2 International Visibility Code [34]

Weather Condition	**Visibility range (km)**
Thick fog	0.2
Moderate fog	0.5
Light fog	0.770 to 1
Thin fog/heavy rainfall (25mm/hr)	1.9 to 2
Haze/medium rain (12.5mm/hr)	2.8 to 4
Clear weather /drizzle (0.25mm/hr)	18 to 20
Very clear weather	23 to 50

The value of the q parameter indicate that the attenuation coefficient, $\beta_a(\lambda)$ depends strongly on the optical wavelength employed at all visibility ranges of the atmosphere. The attenuation coefficient decreases with increase in wavelength. The Kruse Model will be employed to estimate the atmospheric attenuation of Ghana.

3.2.1 Atmospheric Visibility Measurements of Ghana

The successful implementation of FSO systems depends largely on the local atmospheric conditions. Visibility measurement data for Kumasi, Navrongo, Accra, Bole, Kete-Krachi and Wa (see figure 3.1) were taken from the Ghana Meteorological Agency for analysis [39]. The visibility measurements are shown in Appendix A. Atmospheric visibility was measured every three hours in a day. Thus eight visibility measurements were collected daily for two years. For the two years (i.e. years 2010 and 2011), a total of 5840 visibility measurements were collected for each of the six cities under research. Based on the visibility measurements, we will estimate the level of attenuation in each of the six cities and estimate the probability of encountering such atmospheric attenuation conditions.

Fig. 3.1 Map of Ghana showing cities under research [40]

3.3 Atmospheric Turbulence

The optical wave propagating through the atmosphere is still attenuated even under clear weather conditions without absorption and scattering in a process called Index-of-Refractive Turbulence. The temperature inhomogeneity of the atmosphere causes changes in the index of refraction of the atmosphere leading to the formation of eddies. These eddies act like refractive prisms with changing refractive indices. Random variations of the earth's atmosphere distort the optical wave front. The optical signals are refracted out of their straight line trajectory. The received signal therefore fluctuates randomly.

Temporal and spatial variations of intensity within the receiver occur as a result. This effect is called scintillations. The scintillation index is used as a measure of the scintillations. It is the normalized variance of the optical intensity. It is an analytical measure of the total amount of turbulence along the propagation path. In this thesis, we will assume weak turbulence along the propagation path. For a spherical optical wave and assuming weak level of turbulence, the scintillation index can be given as [2]:

$$\sigma_{si} = 0.50 * C_n^2 * k^{7/6} * L^{11/6} \quad \textbf{(10)}$$

Where $k = \dfrac{2\pi}{\lambda}$ is the optical wavenumber (m^{-2})

L[m] is length of the propagation path

C_n^2 [$m^{-2/3}$] is index of refraction profile parameter

C_n^2 [$m^{-2/3}$] can be estimated with the modified Huffnagel-Vally model [2]. Considering a height, h, above ground the refractive index profile parameter is given as:

$$C_n^2\left[m^{-2/3}\right] = 0.00594\left(\frac{21}{27}\right)^2\left(\frac{h}{10^5 m}\right)\exp\left(-\frac{h}{1000m}\right) + 2.7*10^{-16}\exp\left(-\frac{h}{1500m}\right) + 1.7*10^{-14}\exp\left(-\frac{h}{100m}\right) \quad \textbf{(11)}$$

The refractive index profile is dependent on the height of the transceiver above ground. The graph of figure 3.2 shows the dependence of C_n^2 [$m^{-2/3}$] on the height above ground.

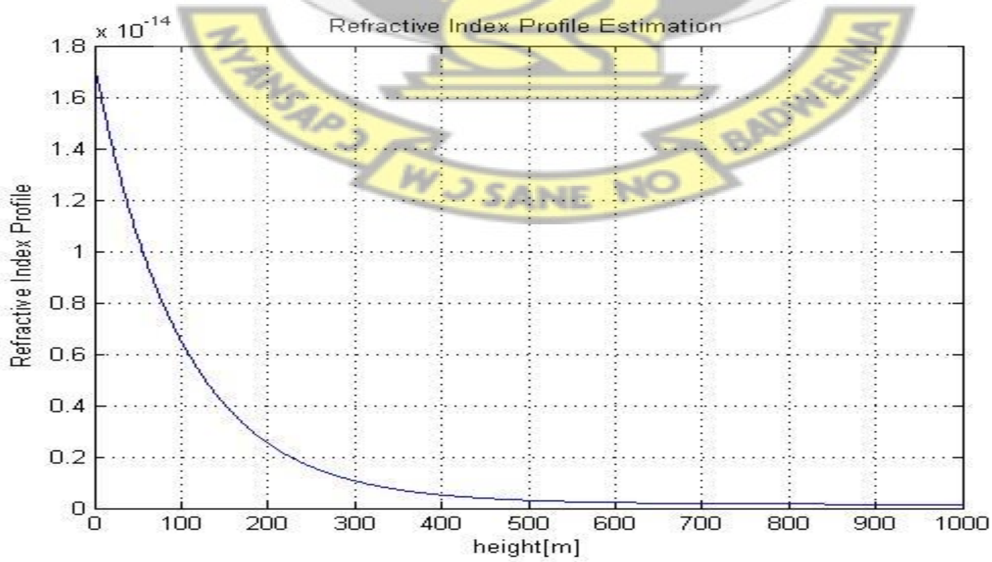

Fig 3.2 Refractive index profile, C_n^2 [$m^{-2/3}$] as a function of height above ground

The scintillation index varies with changes in the refractive index parameter and increases with increase in the propagation path length, L.

As shown in fig 3.3, the scintillation index increases significantly with the propagation path length and introduces significant amount of attenuation into the transmitted signal. This requires the necessary margin to compensate for such losses.

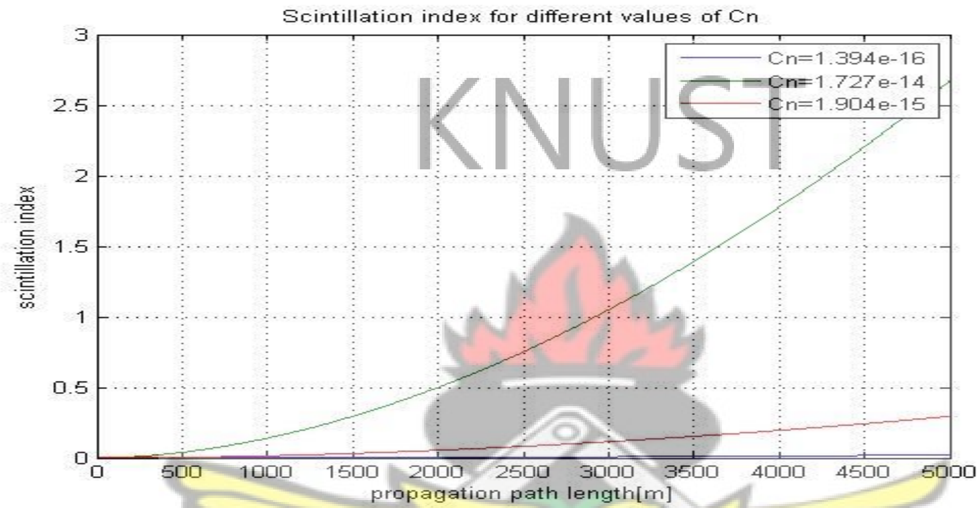

Fig 3.3 Scintillation index varying with path length with different values of C_n^2 [$m^{-2/3}$]

3.3.1 Modeling Fading Loss due to Scintillation Effects

Amplitude fading resulting from scintillation effects can be modeled by statistical approach for example gamma-gamma distribution, the lognormal distribution etc. In this thesis, we will derive an expression to estimate the margin to compensate for losses due to scintillation using the lognormal statistical model. Analysis presented in [12] and [13] show that the lognormal model adequately describes optical signal reception. Measurements by real systems in [41] and [42] show the lognormal distribution satisfactorily models the dynamics of the received optical signal. In this section, we will derive an expression to estimate the necessary margin to compensate for losses due to scintillation.

The probability density function (PDF) and cumulative density functions (CDF) of the optical signal received, X, can be stated respectively as:

$$fx(x) = \frac{1}{x\sigma_x\sqrt{2\pi}} \exp\left[\frac{-(\ln x - \mu_x)^2}{2\sigma_x^2}\right] \qquad \text{For } x > 0 \qquad \textbf{(12)}$$

$$Fx(X) = \frac{1}{2} erfc\left[\frac{-\ln x - \mu_x}{\sigma_x^2\sqrt{2}}\right] \qquad \textbf{(13)}$$

Where erfc(.) denotes the complementary error function. μ_x and σ_x are the mean and standard deviation respectively of the lognormal probability density function (PDF). The expected value, E[X] of the lognormal PDF is the expected value of the analog signal received. Similarly, the variance of the lognormal PDF, var[X] is the variance of the signal received. E[X] and var[X] are expressed respectively as:

$$E[X] = \exp\left(\mu_x + \frac{\sigma_x^2}{2}\right) \qquad \textbf{(14)}$$

$$\text{var}[x] = \left[\exp\left(\sigma_x^2\right) - 1\right] * \exp(2\mu_x + \sigma_x^2) \qquad \textbf{(15)}$$

The scintillation index of a signal is defined as the ratio of the variance to the square of the expected value of the signal received.

$$\text{Scintillation index, } \sigma_{si} = \frac{\text{var[X]}}{(E[X])^2} \qquad \textbf{(16)}$$

Substituting equations (14) and (15) into (16) yields:

$$\sigma_{si}^2 = \frac{[\exp(\sigma_x^2) - 1] * \exp(2\mu_x + \sigma_x^2)}{\exp\left(\mu_x + \frac{\sigma_x^2}{2}\right) * \exp\left(\mu_x + \frac{\sigma_x^2}{2}\right)} = \exp\left(\sigma_x^2\right) - 1 \qquad \textbf{(17)}$$

The scintillation index depends strongly on the lognormal parameter, σ_x as evident in equation (17). The power scintillation index is the variance of the power received normalized by the square of the expected value of the power received. Since the lognormal PDF models the received power, Pr, the scintillation index which represents the general case can be substituted with the power scintillation index. Equation (17) can therefore be expressed as:

Power scintillation index, $\sigma_{pi}^{2} = \exp\left(\sigma_{x}^{2}\right) - 1$ **(18)**

We can therefore substitute into equation (12), x=Pr. Again, we must normalize Pr by the mean of the power received, $\tilde{Pr}$ because the area under the PDF curve must always be equal to 1. Equation (12) can therefore be written as:

$$fp(\mathrm{Pr}) = \frac{1}{\mathrm{Pr}\,\sigma_{x}\sqrt{2\pi}} \exp\left(\frac{-[\ln \frac{\mathrm{Pr}}{\tilde{\mathrm{Pr}}} - \mu_{x}]^{2}}{2\sigma_{x}^{2}} \right) \quad \textbf{(19)}$$

The lognormal parameter σ_{x}^{2} can be obtained by solving equation (18) as:

$$\sigma_{x}^{2} = \ln(\sigma_{pi}^{2} + 1) \quad \textbf{(20)}$$

Assuming that the expected value of the lognormal PDF is equal to 1, μ_{x} can be obtained by solving equation (14) as:

$$\mu_{x} = \frac{-\sigma_{x}^{2}}{2} = -\frac{1}{2}\ln(\sigma_{pi}^{2} + 1) \quad \textbf{(21)}$$

Assuming that the FSO system works only if the optical power received is higher than the receiver sensitivity, R_s, the probability, P, that the FSO system will not work can be obtained by integrating over the PDF function with limits between 0 and R_s.

$$P(R_s \geq \mathrm{Pr}) = \int_{0}^{R_s} fp(\mathrm{Pr})\, d\,\mathrm{Pr} \quad \textbf{(22)}$$

The difference between the average power received, $\tilde{Pr}$ and the receiver sensitivity, R_s for system to function normally can be regarded as additional fading loss. The necessary margin must be incorporated to compensate for such loss.

$$F_{sl} = \tilde{\mathrm{Pr}} - R_s \quad \textbf{(23)}$$

Modifying (23) to reflect the loss in decibels, we obtain:

$$F_{sl}(dB) = 10\log\left(\frac{\tilde{P}r}{R_s}\right) \quad \textbf{(24)}$$

The system outage probability, P can be obtained from the CDF of the lognormal distribution.

$$P(\tilde{P}_r \leq R_s) = \frac{1}{2}erfc\left[\frac{-\ln\frac{R_s}{\tilde{P}_r} - \mu_x}{\sigma_x\sqrt{2}}\right] \quad \textbf{(25)}$$

We can obtain the fading loss, F_{sl}(dB) by solving equation (25) for $\frac{\tilde{P}_r}{R_s}$.

$$-\ln\frac{R_s}{\tilde{P}_r} = \sigma_x\sqrt{2}erfc^{-1}(2P) + \mu_x \quad \textbf{(26)}$$

$$-\ln\frac{R_s}{\tilde{P}_r} = \ln\frac{\tilde{P}_r}{R_s}$$

$$\frac{\tilde{P}_r}{R_s} = \exp\left[\sigma_x\sqrt{2}erfc^{-1}(2P) + \mu_x\right] \quad \textbf{(27)}$$

The margin to compensate for the fading loss, F_{sl}(dB) can be expressed as:

$$F_{sl}[dB] = 10\log\left(\frac{\tilde{P}_r}{R_s}\right) = 10\log\left[\exp\left(\sigma_x\sqrt{2}erfc^{-1}(2P) + \mu_x\right)\right] \quad \textbf{(28)}$$

Substituting equations (20) and (21) into equation (28) we obtain:

$$F_{sl}[dB] = 10\log\left[\exp\left(\sqrt{2\ln(\sigma_{pi}^2 + 1)}erfc^{-1}(2P) - 0.5\ln(\sigma_{pi}^2 + 1)\right)\right] \quad \textbf{(29)}$$

It can be seen from the above equation (29) that the necessary margin to compensate for fading loss due to scintillation is dependent on the power scintillation index and the allowable system outage probability. Therefore the necessary margin must be included in the link equation to compensate for such losses.

3.4 Optical Divergence Loss

The optical beam propagates with an associated beam divergence loss even without any atmospheric losses. The optical beam from the source spreads out due to diffraction. If the receiver aperture area is less than the area of the spread beam, only a percentage of the transmitted beam is captured by the receiver aperture. This results in loss of optical power as shown in figure 3.4. We will use the analysis and model presented in [6] and [34] to estimate the optical divergence loss.

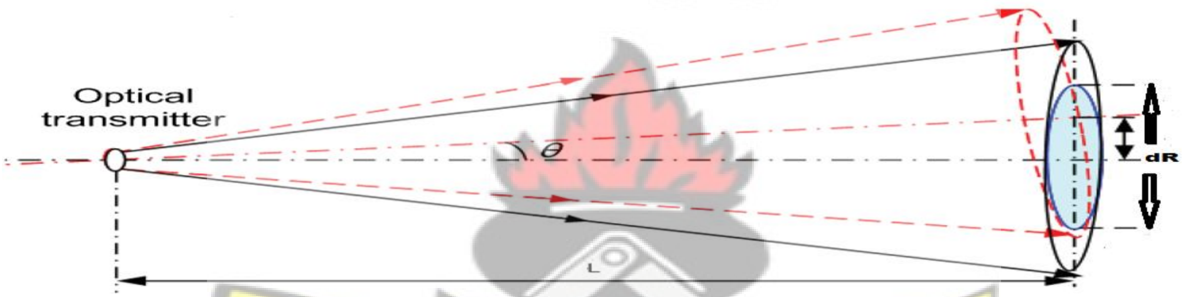

Fig. 3.4 Optical divergence

The diffraction limited angle is approximately given by [34] as:

$$\theta \cong \frac{\lambda}{d_T} \text{ [rad]} \qquad \textbf{(30)}$$

Where d_T: the transmit aperture diameter

The receive optical power can be expressed as

$$P_r = P_t * G_t * G_r * R_L \qquad \textbf{(31)}$$

Where G_t: gain of transmit antenna

G_r: gain of receive antenna

R_L: range loss

The transmit antenna gain, receive antenna gain and range loss are respectively given as:

$$G_t = \frac{4\pi}{\Omega} \qquad \textbf{(32)}$$

Where Ω is the beam solid angle given by $\Omega = \frac{\pi\theta^2}{4}$

$$G_r = \frac{4\pi}{\lambda^2} * A_r \quad \textbf{(33)}$$

Where A_r is the area of the receive aperture

$$R_L = \left(\frac{\lambda}{4\pi L}\right)^2 \quad \textbf{(34)}$$

The received optical power after travelling a distance, L, can therefore be expressed by substituting equations (32), (33) and (34) into equation (31) as:

$$P_r = P_t * \frac{A_r}{L^2\Omega} \quad \textbf{(35)}$$

Substituting $\Omega = \frac{\pi\theta^2}{4}$ into equation (35), we obtain:

$$P_r = \frac{4P_tA_r}{\pi L^2\theta^2} \quad \textbf{(36)}$$

Substituting $\theta \cong \frac{\lambda}{d_T}$ and $A_r = \frac{\pi d_R^2}{4}$ into equation (36), we obtain:

$$\frac{P_r}{P_t} = \left(\frac{d_R d_T}{L\lambda}\right)^2 \quad \textbf{(37)}$$

The geometric loss, L_G [dB] is given as:

$$L_G[dB] = 10\log\left(\frac{P_t}{P_r}\right) \quad \textbf{(38)}$$

$$L_G[dB] = -20\log\left(\frac{d_R d_T}{L\lambda}\right)$$

The geometric loss can also be expressed in terms of the optical divergence angle as:

$$L_G[dB] = -20\log\left(\frac{d_R}{L\theta}\right) \quad \textbf{(39)}$$

Equation (39) suggests that the optical geometric loss decreases when the receiver aperture diameter is increased and the divergence angle is reduced. Again the optical geometric loss increases with increase in the propagation path length. From equation (39), it is clear that an optical source with a very narrow divergence angle is preferred to a source with a wide divergence angle in terrestrial FSO systems. However wide divergence angle optical sources are more desirable in short range FSO links. This helps to ease the alignment requirement, compensate for building sway and exclude the necessity for active tracking systems at the expense of an increase in geometric loss. A typical FSO transceiver has a beam divergence angle of 2-10mrad for systems without active tracking and 0.05-1.0mrad for systems with active tracking [4].

3.5 Link Budget Analysis and System Availability

The FSO system performance can be quantified in terms of the link margin. The link margin is obtained from the optical link equation. Similar to Radio Frequency Communication links, the FSO system designer begins with the transmitted power and identifies all power losses along the propagation path. The power level received is compared with the receiver sensitivity to obtain the link margin. The receiver sensitivity represents the minimum amount of optical power needed for the system to achieve a given level of performance, for instance a BER of 10^{-9}. The individual link interruptions occur when the level of the optical power received drops below the receiver sensitivity. The ITU Recommendation ITU-R P.1814 [34] states the optical link equation as:

$$P_r = P_T - \beta_a(\lambda) * L - L_G - F_{sl} - A_{sys} \quad \textbf{(41)}$$

$$L_M = P_r - R_s \quad \textbf{(42)}$$

Where Pr : the optical power received in dBm

P_T : the optical power transmitted in dBm

$\beta_a(\lambda)$: the aerosol scattering attenuation in dB/km

L: the propagation path length in km

L_G: the optical divergence (geometric) loss in dB

F_{sl} : the scintillation loss in dB

L_M: Link Margin in dB

Asys: the system dependent losses in dB; This represents all other system dependent losses including misalignment of the beam direction, receiver optical losses, loss due to beam wander, and reduction in sensitivity due to ambient light (solar radiation).

The aerosol scattering attenuation, scintillation losses and geometrical losses are estimated by equations 8, 29 and 39 respectively. One major importance of the optical link equation is in determining the achievable link range for a given receiver sensitivity and link margin. We will use the system parameters in table 3.3 to show how the achievable optical link range changes with link margin for different values of visibility.

Table 3.3 Typical FSO System Parameters

Parameter	**Typical Value**
Transmit Power	14dBm
Transmit Beam Divergence Angle	2mrad
Wavelength	850nm
Receiver Aperture Diameter	8cm
Receiver Sensitivity	-30dBm
System Losses	2dB

3.5.1 System Availability

When the power received falls below the receiver sensitivity, the optical link becomes unavailable. The availability of the optical link depends largely on the conditions of the atmosphere and it is the main limiting factor in the system availability. The probability that the optical link will be available is the percentage of time during which the power received is equal to or greater than the sensitivity of the receiver. The system availability can be stated mathematically as:

$$Availability = \Pr obability(\Pr \geq R_s) \quad \textbf{(43)}$$

We will use the parameters of a typical commercial FSO system to estimate the system availability in all six cities under research. Its specifications are listed in table 3.4

Table 3.4 Technical Specifications of the MRV TereScope 5000

Parameter	**Value**
Light Source	Laser
Eye Safety	Class 1M
Transmit Power	100mW (20dBm)
Transmit Beam Divergence Angle	2mrad
Wavelength	850nm
Detector	Silicon Photodiode
Receiver Sensitivity	-46dBm
Receiver Field of View	5mrad
Data Rate	155Mbps

3.6 Summary

In this chapter, we modeled the atmospheric transmission medium of FSO and the level of attenuation introduced by the weather. We used the Kruse model to estimate the effect of the local weather on the transmission of optical signals. We discussed the effects of scintillation and derived an expression to estimate the margin needed to compensate for losses due to scintillation effects. The optical geometric divergence loss is discussed and the chapter ends with discussions on optical link equation and system availability.

Chapter 4

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, we will estimate atmospheric specific attenuation and probability of encountering any atmospheric attenuation condition in Ghana. Results of the effects of scintillation will be discussed. FSO system availability in six Ghanaian cities will be estimated based on the atmospheric attenuation estimation.

4.2 Atmospheric Specific Attenuation Estimation of Ghana

In this section, we estimate the attenuation caused by the Ghanaian atmosphere based on the visibility measurements (see Appendix A) using the Kruse model of equations (8) and (9). The graphs that follow show the attenuation coefficient, $\beta_a(\lambda)$ of Kumasi, Navrongo, Accra, Bole, Kete-Krachi and Wa in dB/km. The specific attenuation is estimated for three optical wavelengths typically used in commercial FSO systems (i.e. 850nm, 1300nm and 1550nm). On the X-axis, is the time of the year during which the visibility measurement was taken. On the Y-axis, is the attenuation (dB/km) estimated for each visibility measurement taken in the year.

The estimated optical attenuation for Kumasi is shown in figures 4.7a-c for the year 2010. The highest estimated attenuation was 128.2316dB/km on 1550nm wavelength, 134.5050dB/km on 1300nm wavelength and 150.9547dB/km on 850nm wavelength. This occurred in the month of January where visibility conditions are relatively poor in Kumasi. The lowest estimated attenuation was 0.1767dB/km on 1550nm wavelength, 0.2221dB/km on 1300nm wavelength and 0.3859dB/km on 850nm wavelength. An annual average of

0.8216dB/km on 1550nm wavelength, 0.9564dB/km on 1300nm wavelength and 1.4086dB/km on 850nm were estimated. The results are summarized in table 4.1

Table 4.1 Summary of Estimated Specific Attenuation of Kumasi: Year 2010

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Jan	0.2325	128.2316	1.9401	0.5078	150.9547	2.9279	0.2923	134.5050	2.1755
Feb	0.2008	2.3628	0.4925	0.4385	3.9225	1.0258	0.2524	2.7408	0.6101
Mar	0.2008	27.1750	2.3559	0.4385	35.2074	3.4880	0.2524	29.3154	2.6350
April	0.2008	27.1750	0.4674	0.4385	35.2074	0.9096	0.2524	29.3154	0.5654
May	0.1767	12.0985	0.3830	0.3859	16.7658	0.7830	0.2221	13.3111	0.4712
June	0.1767	27.1750	0.5563	0.3859	35.2074	1.0249	0.2221	29.3154	0.6619
July	0.1767	2.3628	0.3600	0.3859	3.9225	0.7649	0.2221	2.7408	0.4486
Aug	0.1841	2.9854	0.3936	0.4020	4.8101	0.8206	0.2314	3.4328	0.4876
Sept	0.1767	3.9583	0.4139	0.3859	6.1633	0.8517	0.2221	4.5062	0.5106
Oct	0.1767	16.9829	0.4790	0.3859	22.8429	0.9212	0.2221	18.5227	0.5781
Nov	0.1767	16.9829	0.4687	0.3859	22.8429	0.9136	0.2221	18.5227	0.5680
Dec	0.2008	59.5948	1.4720	0.4385	73.1938	2.3725	0.2524	63.2912	1.6828
Year	**0.1767**	**128.2316**	**0.8216**	**0.3859**	**150.9547**	**1.4086**	**0.2221**	**134.5050**	**0.9564**

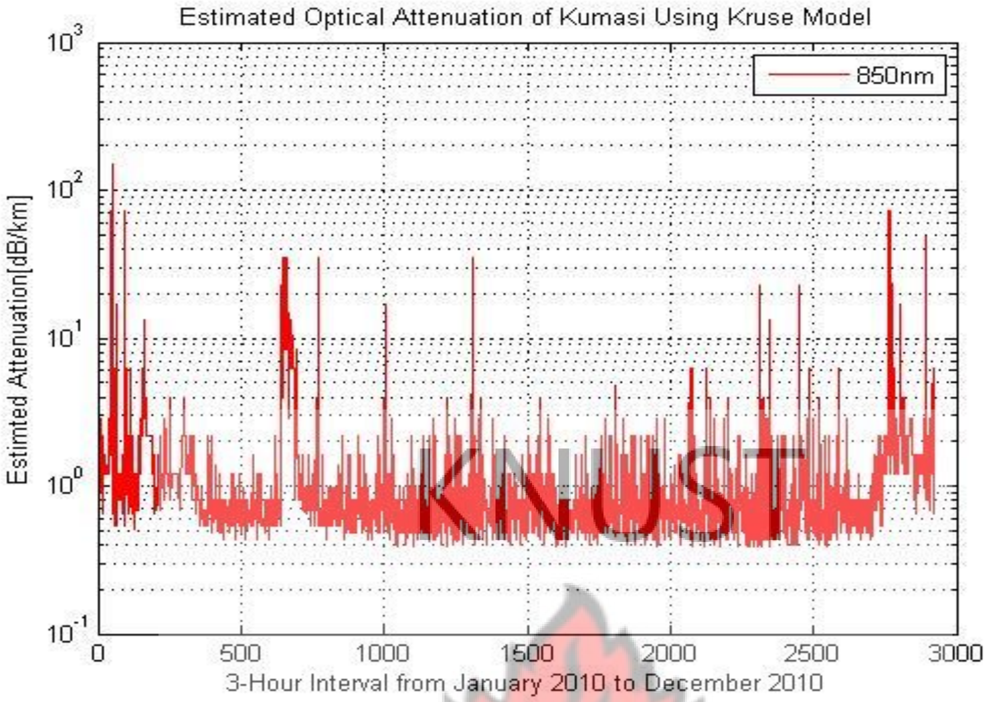

Fig 4.1a Estimated Attenuation coefficient (dB/km) for Kumasi at 850nm

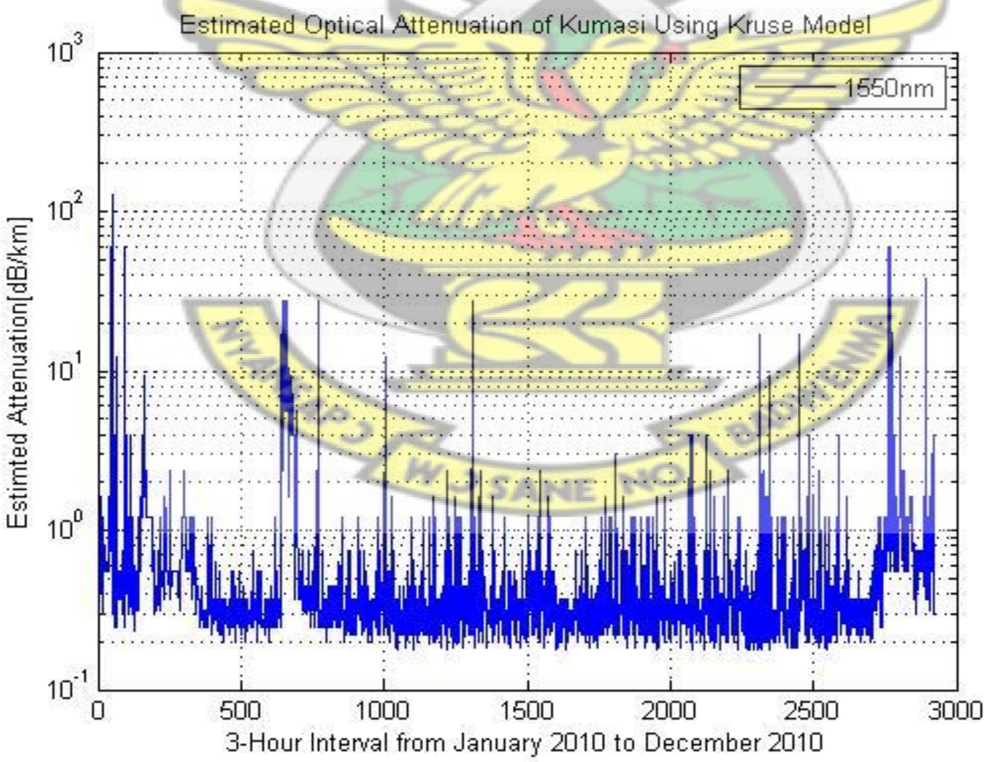

Fig 4.1b Estimated Attenuation coefficient (dB/km) for Kumasi at 1550nm

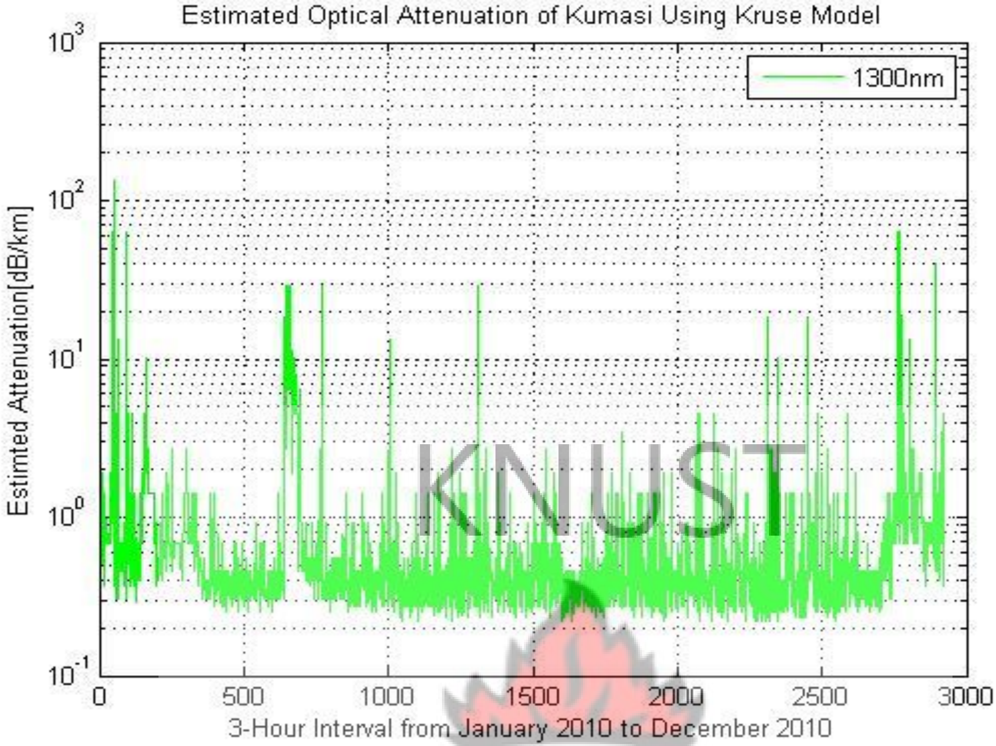

Fig 4.1c Estimated Attenuation coefficient (dB/km) for Kumasi at 1300nm

The estimated optical attenuation for Kumasi is shown in figures 4.1d-f for the year 2011. The highest attenuation estimated for the year 2011 was 128.2316dB/km on 1550nm wavelength, 134.5050dB/km on 1300nm wavelength and 150.9547dB/km on 850nm wavelength. The lowest estimated attenuation was 0.1105dB/km on 1550nm wavelength, 0.1388dB/km on 1300nm wavelength and 0.2412dB/km on 850nm wavelength. An annual average of 1.0771dB/km on 1550nm wavelength, 1.2307dBkm on 1300nm wavelength and 1.7310dB/km on 850nm wavelength were estimated. The results are summarized in table 4.2. It can be observed that the average specific attenuation estimated for the years 2010 and 2011 in Kumasi showed very small variation.

Table 4.2 Summary of Estimated Specific Attenuation of Kumasi: Year 2011

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.2008	59.5948	6.1532	0.4385	73.1938	8.6191	0.2524	63.2912	6.7823
Feb	0.1699	3.95833	0.4394	0.3711	6.1633	0.9131	0.2136	4.5062	0.5438
Mar	0.1841	21.0031	0.4155	0.4020	27.7608	0.8286	0.2314	22.7904	0.5067
April	0.1699	2.3628	0.3427	0.3711	3.9225	0.7228	0.2136	2.7408	0.4261
May	0.1767	3.9583	0.3454	0.3859	6.1633	0.7181	0.2221	4.5062	0.4275
June	0.1105	59.5948	0.6018	0.2412	73.1938	1.0561	0.1388	63.2912	0.7042
July	0.1841	21.0031	0.4415	0.4020	27.7608	0.8759	0.2314	22.7904	0.5376
Aug	0.1841	128.2316	0.9715	0.4020	150.9547	1.5130	0.2314	134.5050	1.0962
Sept	0.1636	27.1750	0.4714	0.3573	35.2074	0.9080	0.2057	29.3154	0.5685
Oct	0.1636	1.6229	0.3651	0.3573	2.8351	0.7821	0.2057	1.9108	0.4561
Nov	0.1841	1.6229	0.3307	0.4020	2.8351	0.7097	0.2314	1.9108	0.4134
Dec	0.2209	128.2316	1.9033	0.4824	150.9547	2.9329	0.2777	134.5050	2.1483
Year	**0.1105**	**128.2316**	**1.0771**	**0.2412**	**150.9547**	**1.7310**	**0.1388**	**134.5050**	**1.2307**

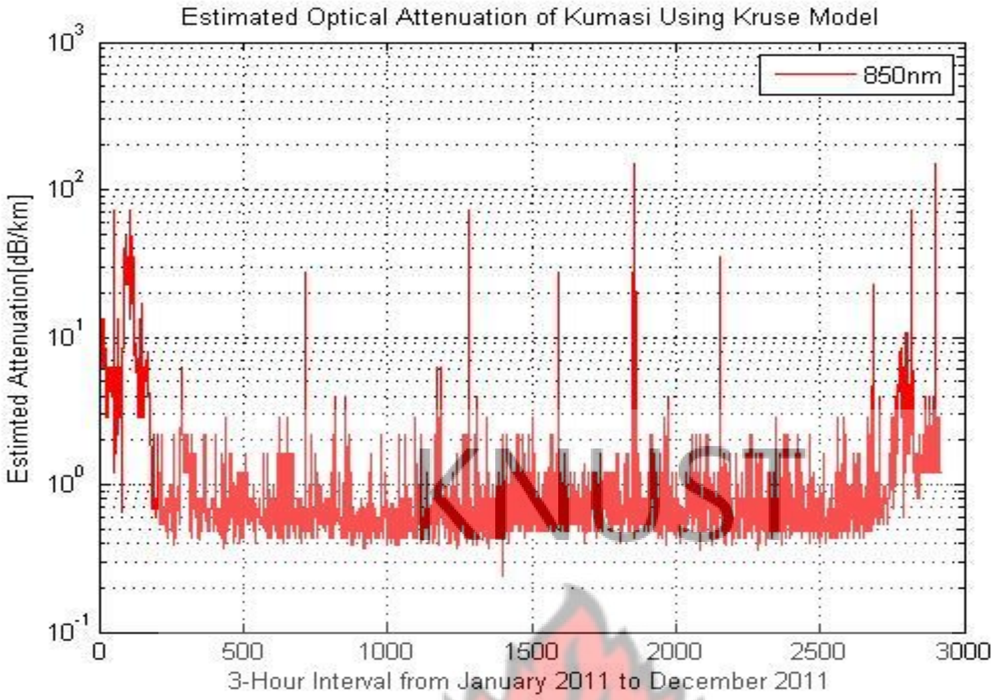

Fig 4.1d Estimated Attenuation coefficient (dB/km) for Kumasi at 850nm

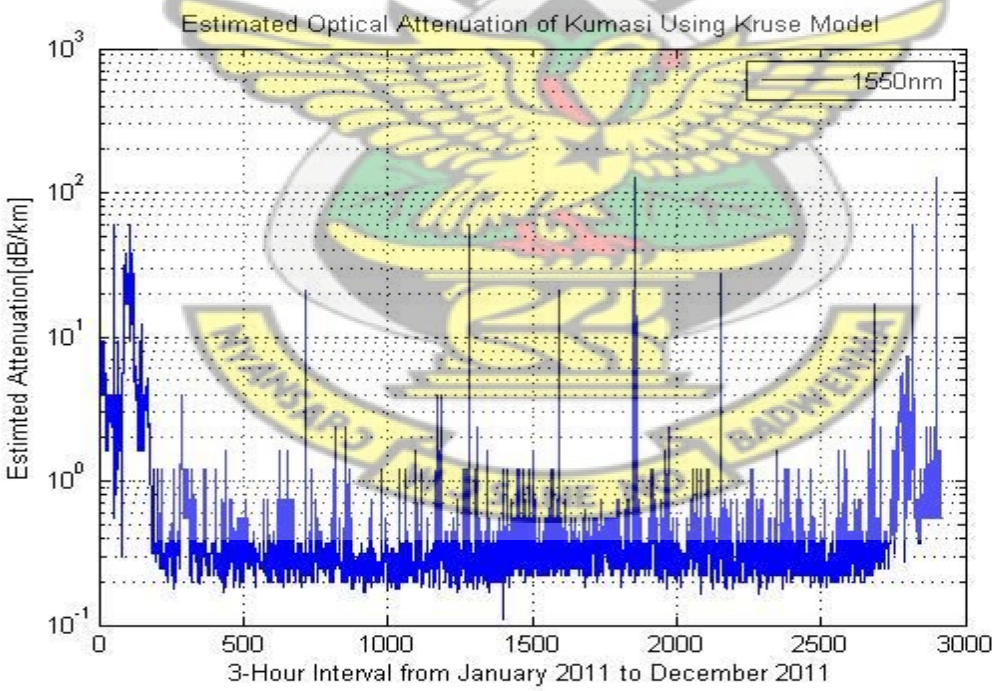

Fig 4.1e Estimated Attenuation coefficient (dB/km) of Kumasi at 1550nm

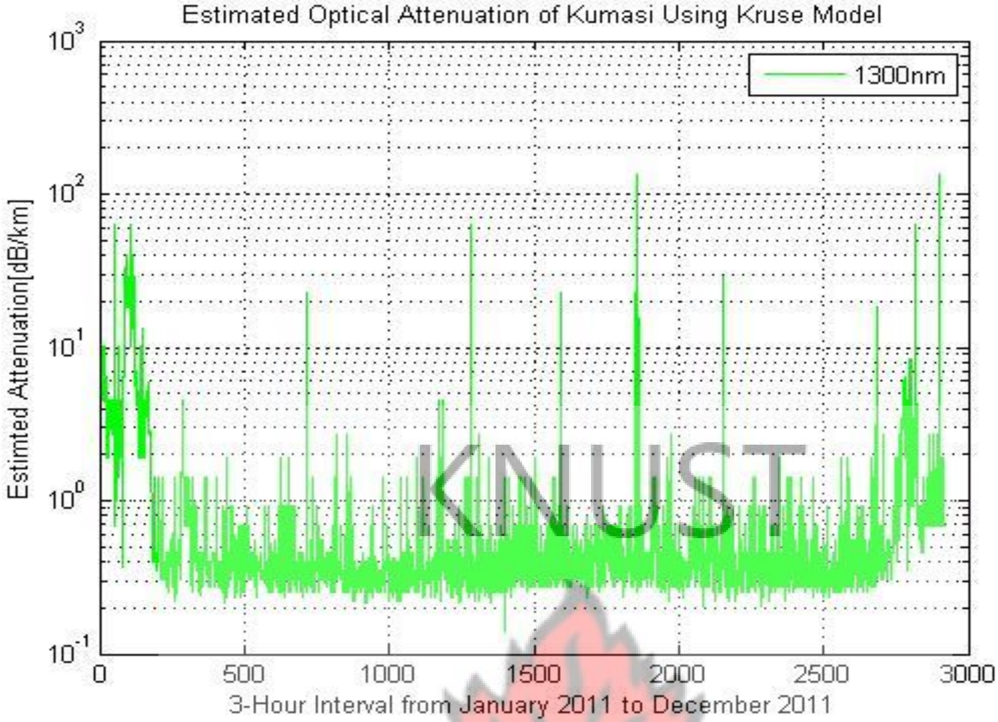

Fig 4.1f Estimated Attenuation coefficient (dB/km) for Kumasi Year at 1300nm

The estimated optical attenuation for Navrongo is shown in figures 4.2a-c for the year 2010. The highest attenuation estimated for the year 2010 was 37.7434dB/km on 1550nm wavelength, 40.4350dB/km on 1300nm wavelength and 47.7555dB/km on 850nm wavelength. The lowest estimated attenuation was 0.2454dB/km on 1550nm wavelength, 0.3085dB/km on 1300nm wavelength and 0.5360dB/km on 850nm wavelength. An annual average of 0.8130dB/km on 1550nm wavelength, 0.9607dB/km on 1300nm wavelength and 1.4647dB/km on 850nm wavelength were estimated. The results are summarized in table 4.3.

Table 4.3 Summary of Estimated Specific Attenuation of Navrongo: Year 2010

Month	Attenuation 1550nm [$dBkm^{-1}$]			Attenuation 850nm [$dBkm^{-1}$]			Attenuation 1300nm [$dBkm^{-1}$]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.4909	3.9583	0.8205	1.0719	6.1633	1.5893	0.6170	4.5062	0.9933
Feb	0.3682	9.2673	0.6714	0.8040	13.1700	1.3476	0.4628	10.2717	0.8219
Mar	0.3682	37.7434	4.2640	0.8040	47.7555	6.1034	0.4628	40.4350	4.7220
April	0.2454	1.6229	0.5220	0.5360	2.8351	1.0726	0.3085	1.9108	0.6439
May	0.3682	0.5523	0.3712	0.8040	1.2059	0.8105	0.4628	0.6941	0.4665
June	0.3682	0.7363	0.3752	0.8040	1.6079	0.8193	0.4628	0.9255	0.4716
July	0.3682	0.5523	0.3763	0.8040	1.2059	0.8218	0.4628	0.6941	0.4730
Aug	0.3156	0.7363	0.3765	0.6891	1.6079	0.8221	0.3966	0.9255	0.4732
Sept	0.3682	1.6229	0.3819	0.8040	2.8351	0.8310	0.4628	1.9108	0.4795
Oct	0.2761	0.7363	0.3526	0.6030	1.6079	0.7701	0.3471	0.9255	0.4432
Nov	0.2761	1.6229	0.5198	0.6030	2.8351	1.0995	0.3471	1.9108	0.6469
Dec	0.3682	1.6229	0.6646	0.8040	2.8351	1.4118	0.4628	1.9108	0.8282
Annual	**0.2454**	**37.7434**	**0.8130**	**0.5360**	**47.7555**	**1.4647**	**0.3085**	**40.4350**	**0.9607**

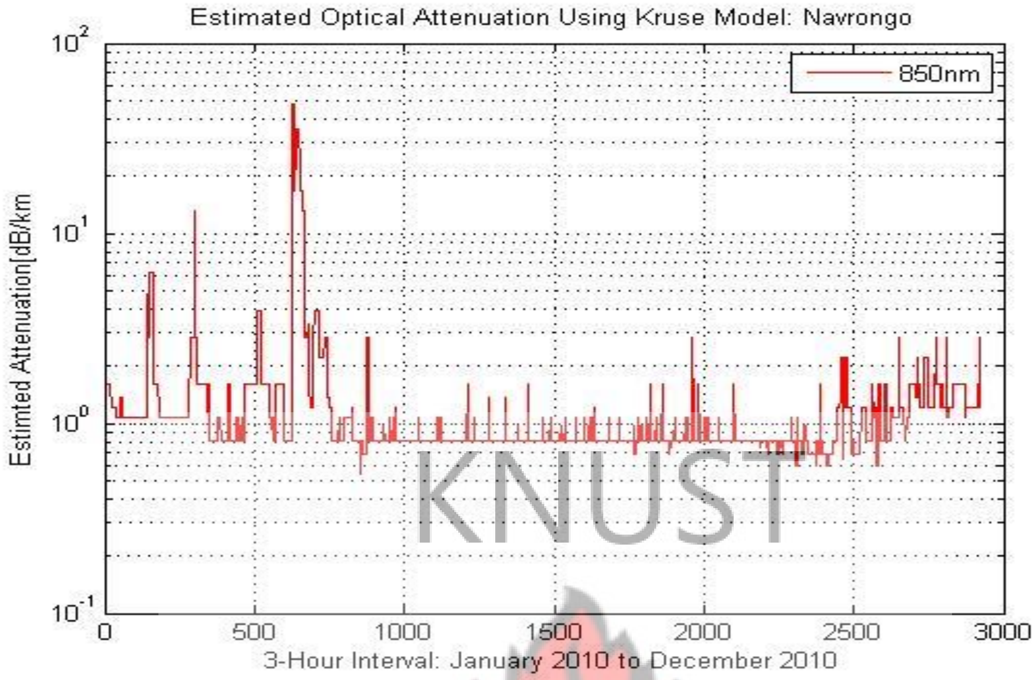

Fig 4.2a Estimated Attenuation coefficient (dB/km) for Navrongo at 850nm

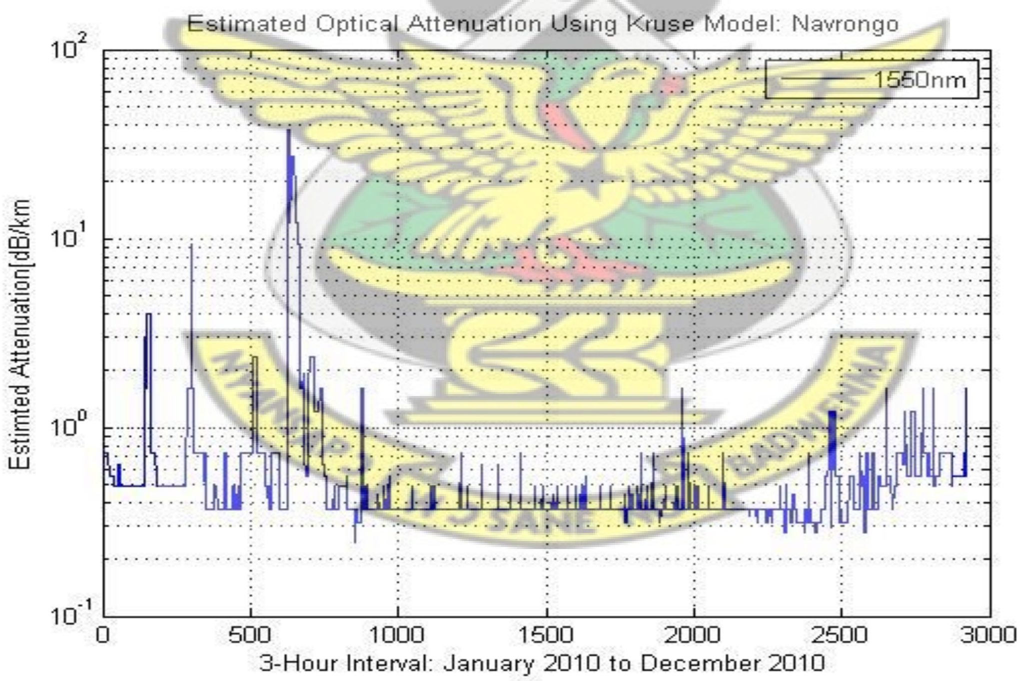

Fig 4.2b Estimated Attenuation coefficient (dB/km) for Navrongo at 1550nm

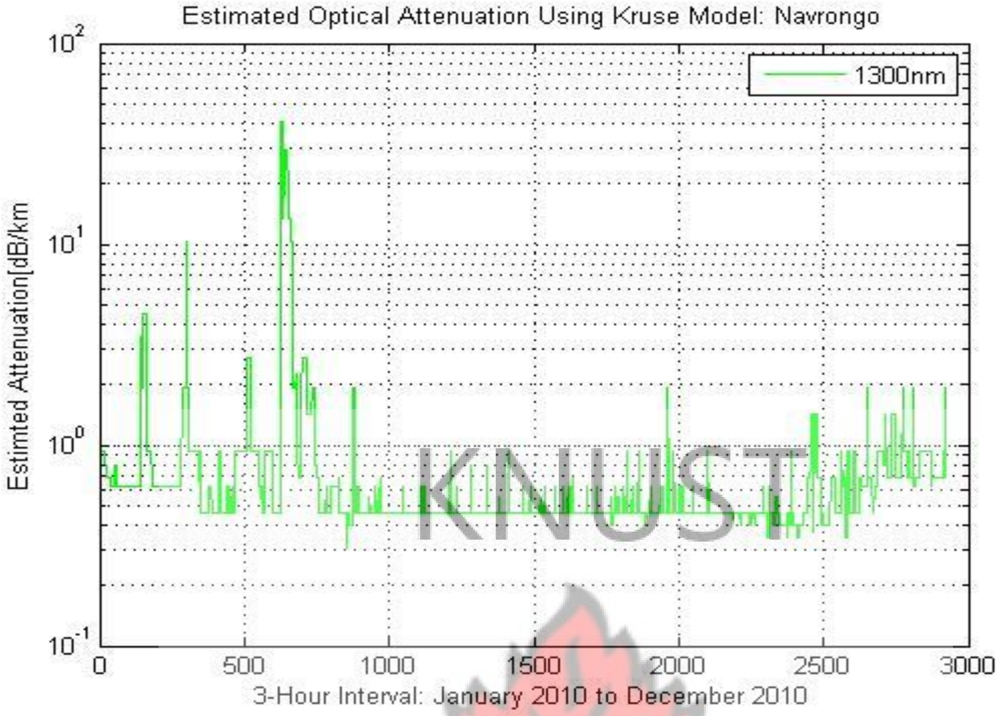

Fig 4.2c Estimated Attenuation coefficient (dB/km) for Navrongo Year at 1300nm

The estimated optical attenuation for Navrongo is shown in figures 4.2d-f for the year 2011. The highest attenuation estimated for the year 2011 was 37.7434dB/km on 1550nm wavelength, 40.4350dB/km on 1300nm wavelength and 47.7555dB/km on 850nm wavelength. The lowest estimated attenuation was 0.2454dB/km on 1550nm wavelength, 0.3085dB/km on 1300nm wavelength and 0.5360dB/km on 850nm wavelength. An annual average of 1.0934dB/km on 1550nm wavelength, 1.2575dB/km on 1300nm wavelength and 1.8008dB/km on 850nm were estimated. The results are summarized in table 4.4. It can be observed that the average specific attenuation estimated for the years 2010 and 2011 in Navrongo shows very small variation.

Table 4.4 Summary of Estimated Specific Attenuation of Navrongo: Year 2011

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Jan	0.5523	37.7434	6.6303	1.2059	47.7555	9.0042	0.6941	40.4350	7.2360
Feb	0.3682	9.2673	0.6012	0.8040	13.1701	1.2425	0.4628	10.2717	0.7423
Mar	0.2761	0.5523	0.3422	0.6030	1.2059	0.7472	0.3471	0.6941	0.4301
April	0.2761	0.5523	0.3884	0.6030	1.2059	0.8482	0.3471	0.6941	0.4882
May	0.2761	0.5523	0.3394	0.6030	1.2059	0.7411	0.3471	0.6941	0.4266
June	0.2761	0.7363	0.3087	0.6030	13.1701	0.6742	0.3471	0.9255	0.3880
July	0.2454	0.5523	0.3046	0.5360	1.2059	0.6651	0.3085	0.6941	0.3829
Aug	0.2761	16.9829	0.4271	0.6030	22.8429	0.8723	0.3471	18.5227	0.5249
Sept	0.2761	0.7363	0.3412	0.6030	1.6079	0.7452	0.3471	0.9255	0.4289
Oct	0.2761	0.6311	0.4062	0.6030	1.3782	0.8870	0.3471	0.7933	0.5105
Nov	0.4909	1.6229	0.6875	1.0719	2.8351	1.4877	0.6170	1.9108	0.8617
Dec	0.5523	12.0985	2.2110	1.2059	16.7658	3.5292	0.6941	13.3111	2.5278
Annual	**0.2454**	**37.7434**	**1.0934**	**0.5360**	**47.7555**	**1.8008**	**0.3085**	**40.4350**	**1.2575**

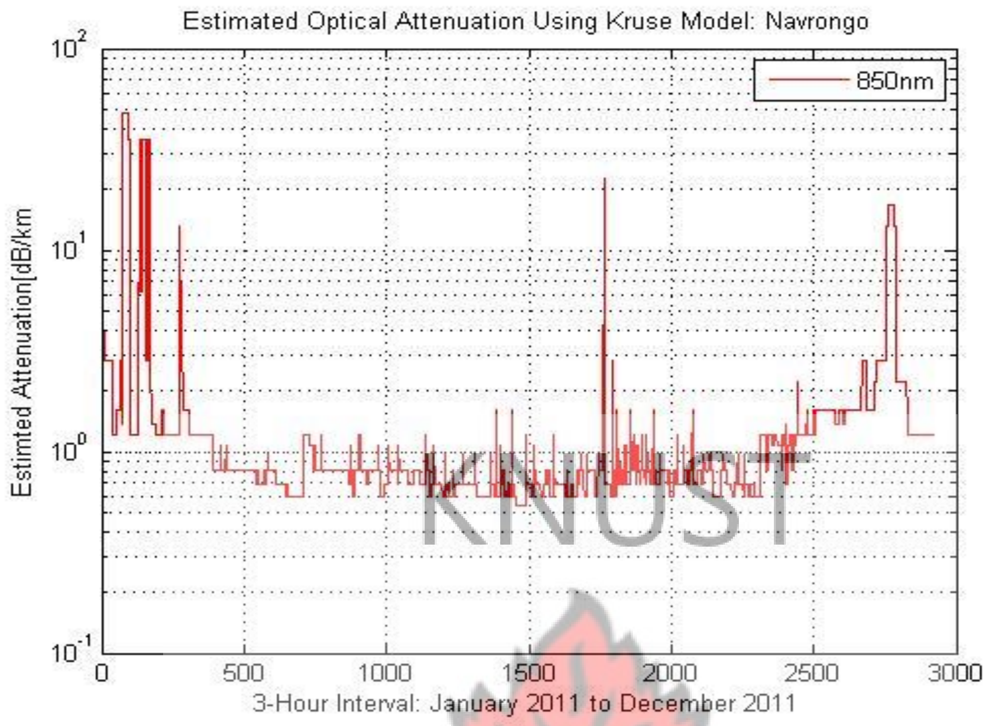

Fig 4.2d Estimated Attenuation coefficient (dB/km) for Navrongo at 850nm

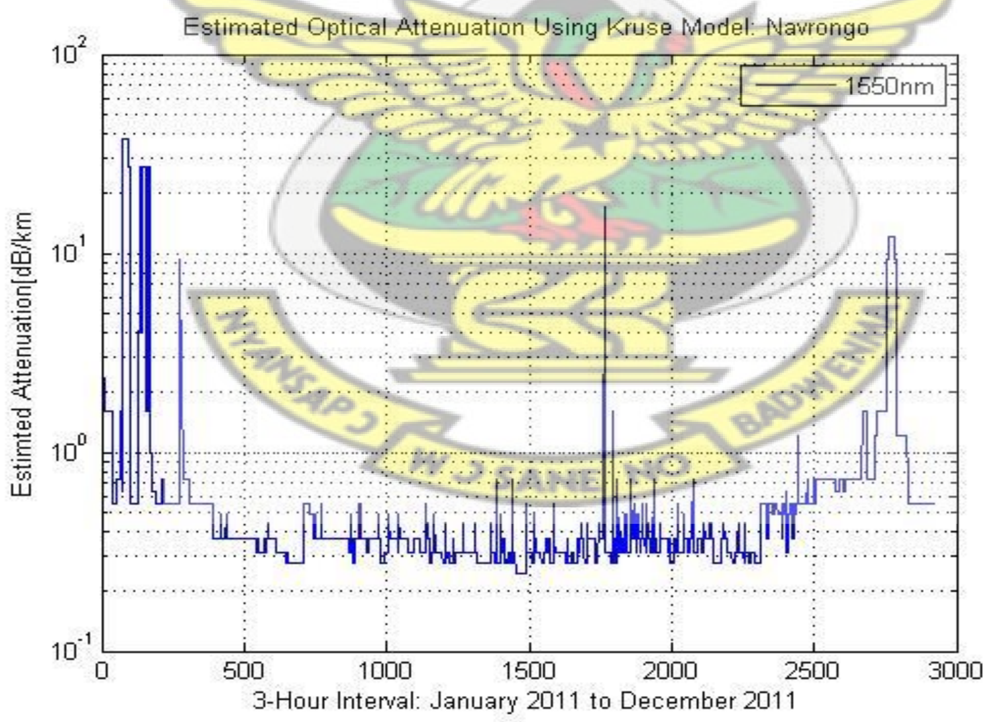

Fig 4.2e Estimated Attenuation coefficient (dB/km) for Navrongo at 1550nm

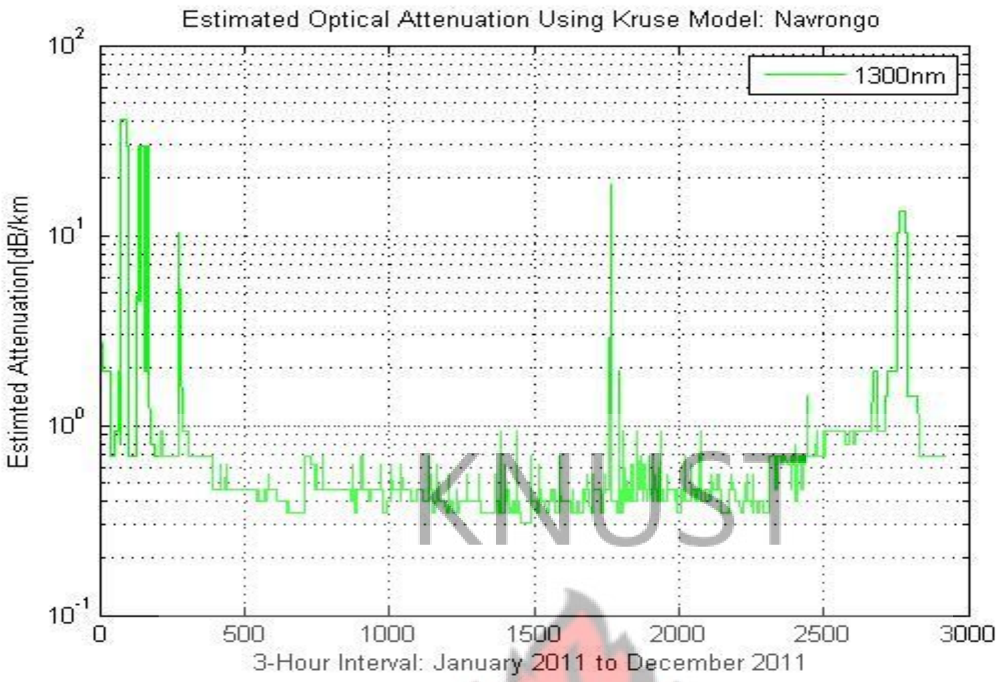

Fig 4.2f Estimated Attenuation coefficient (dB/km) of Navrongo at 1300nm

The estimated optical attenuation for Accra is shown in figures 4.3a-c the year 2010. The highest attenuation estimated for the year 2010 was 21.0031dB/km on 1550nm wavelength, 22.7904dB/km on 1300nm wavelength and 27.7608dB/km on 850nm wavelength. The lowest estimated attenuation was 0.2209dB/km on 1550nm wavelength, 0.2777dB/km on 1300nm wavelength and 0.4824dB/km on 850nm wavelength. An annual average of 0.5134dB/km on 1550nm wavelength, 0.6262dB/km on 1300nm wavelength and 1.0192dB/km on 850nm were estimated. The results are summarized in table 4.5.

Table 4.5 Summary of Estimated Specific Attenuation of Accra: Year 2010

Month	Attenuation 1550nm [$dBkm^{-1}$]			Attenuation 850nm [$dBkm^{-1}$]			Attenuation 1300nm [$dBkm^{-1}$]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.2945	2.9854	0.8111	0.6433	4.8100	1.5460	0.3702	3.4328	0.9781
Feb	0.2454	2.3628	0.5018	0.5360	3.9225	1.0343	0.3085	2.7408	0.6195
Mar	0.2209	21.0031	1.0619	0.4824	27.7608	1.8464	0.2777	22.7904	1.2447
April	0.2209	2.3628	0.3559	0.4824	3.9225	0.7642	0.2777	2.7408	0.4449
May	0.2209	2.3628	0.3388	0.4824	3.9225	0.7319	0.2777	2.7408	0.4243
June	0.2454	12.0985	0.4918	0.5360	16.7658	0.9816	0.3085	13.3111	0.6006
July	0.2454	9.2673	0.4508	0.5360	13.1701	0.9036	0.3085	10.2717	0.5513
Aug	0.2454	3.9583	0.4526	0.5360	6.1633	0.9287	0.3085	4.5062	0.5579
Sept	0.2209	9.2673	0.3885	0.4824	13.1701	0.8088	0.2777	10.2717	0.4808
Oct	0.2209	1.6229	0.3246	0.4824	2.83511	0.7059	0.2777	1.9108	0.4075
Nov	0.2209	1.2054	0.3386	0.4824	2.1984	0.7321	0.2777	1.4372	0.4243
Dec	0.2454	3.9583	0.6284	0.5360	6.1633	1.2230	0.3085	4.5062	0.7625
Annual	**0.2209**	**21.0031**	**0.5134**	**0.4824**	**27.7608**	**1.0192**	**0.2777**	**22.7904**	**0.6262**

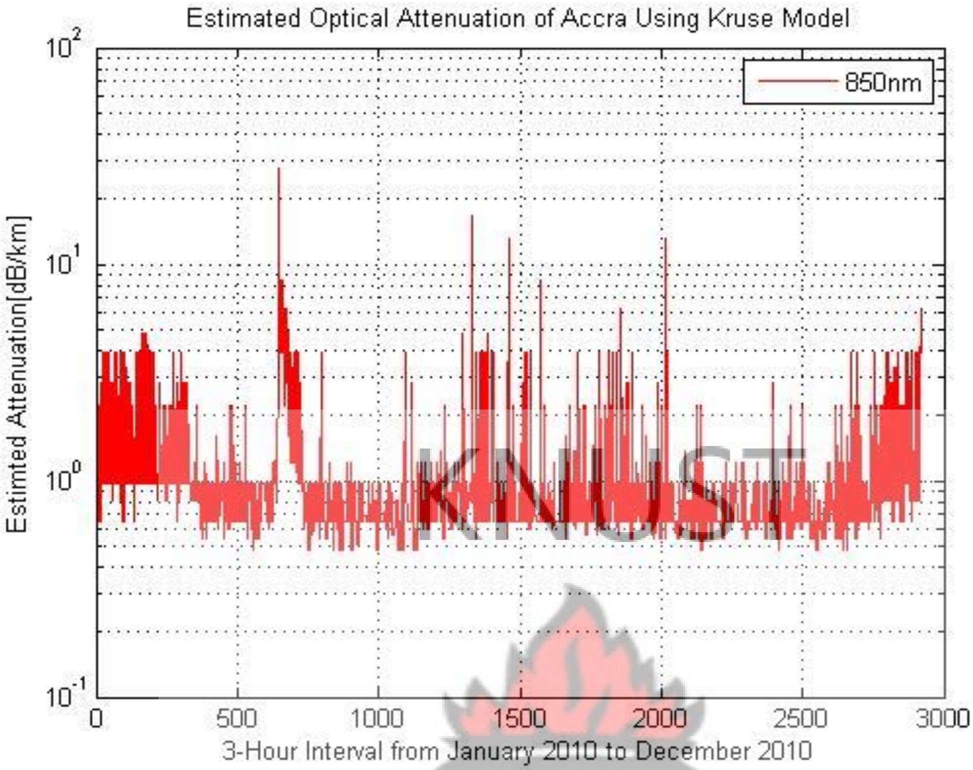

Fig 4.3a Estimated Attenuation coefficient (dB/km) for Accra at 850nm

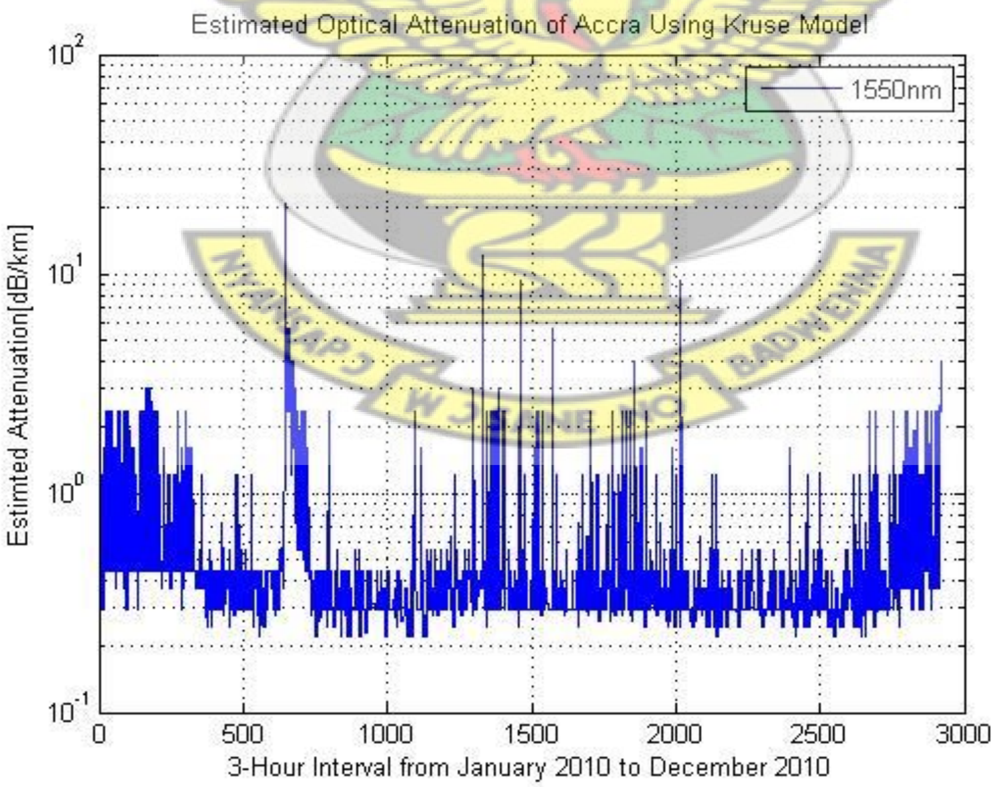

Fig 4.3b Estimated Attenuation coefficient (dB/km) for Accra at 1550nm

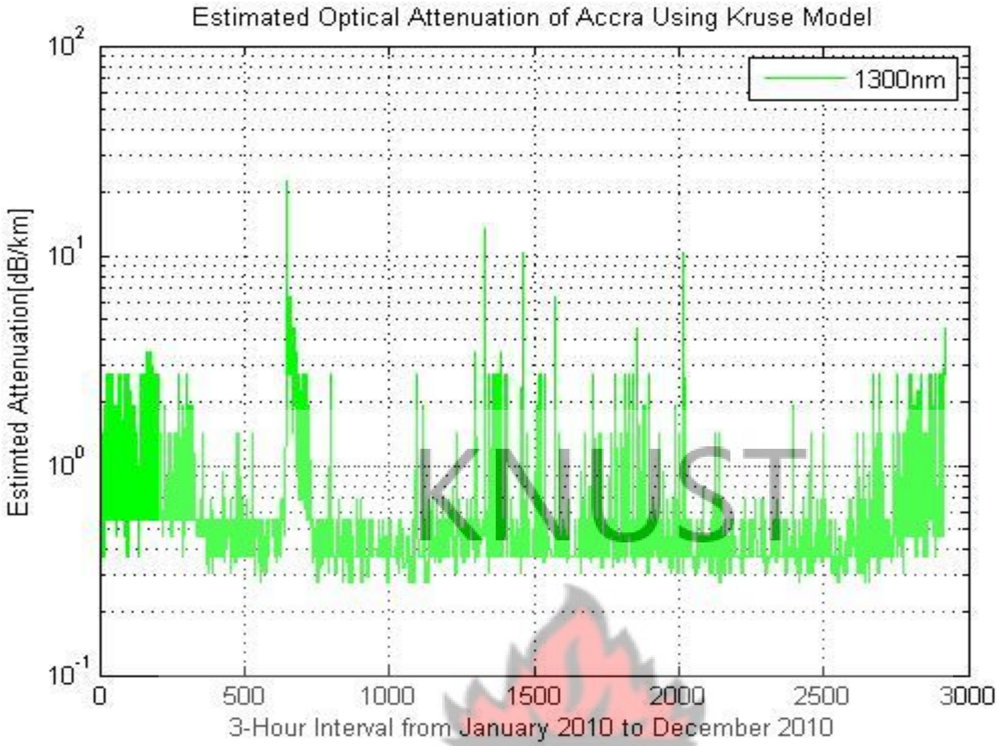

Fig 4.3c Estimated Attenuation coefficient (dB/km) for Accra at 1300nm

The estimated optical attenuation for Accra is shown in figures 4.3d-f for the year 2011. The highest attenuation estimated for the year 2011 was 16.9829dB/km on 1550nm wavelength, 18.5227dB/km on 1300nm wavelength and 22.8429dB/km on 850nm wavelength. The lowest estimated attenuation was 0.2209dB/km on 1550nm wavelength, 0.2777dB/km on 1300nm wavelength and 0.4824dB/km on 850nm wavelength. An annual average of 0.7377dB/km on 1550nm wavelength, 0.8247dB/km and 1.3344dB/km on 850nm was estimated. It can be observed that the average specific attenuation estimated for the years 2010 and 2011 in Accra shows very small variation. The results are summarized in table 4.6.

Table 4.6 Summary of Estimated Specific Attenuation of Accra: Year 2011

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.2945	16.9829	3.5470	0.6432	22.8429	5.3773	0.3702	18.5227	4.0005
Feb	0.2454	3.9583	0.4820	0.5360	6.1633	0.9973	0.3085	4.5062	0.5958
Mar	0.2454	1.2054	0.3411	0.5360	2.1984	0.7415	0.3085	1.4372	0.4282
April	0.2209	1.6229	0.3587	0.4824	2.8351	0.7732	0.2777	1.9108	0.4491
May	0.2209	9.2673	0.4021	0.4824	13.1701	0.8311	0.2777	10.2717	0.4964
June	0.2454	2.9854	0.3964	0.5360	4.8100	0.8388	0.3085	3.4328	0.4933
July	0.2454	12.0985	0.5194	0.5360	16.7659	1.0293	0.3085	13.3111	0.6330
Aug	0.2454	2.3628	0.4077	0.5360	3.9225	0.8687	0.3085	2.7408	0.5085
Sept	0.2209	0.5523	0.3410	0.4824	1.2060	0.7446	0.2777	0.6941	0.4286
Oct	0.2454	1.6229	0.3290	0.5360	2.8351	0.7137	0.3085	1.9108	0.4126
Nov	0.2209	1.6229	0.3697	0.4824	2.8351	0.7864	0.2777	1.9108	0.4610
Dec	0.2945	12.0985	1.2860	0.6432	16.7658	2.2075	0.3702	13.3111	1.5026
Annual	**0.2209**	**16.9829**	**0.7377**	**0.4824**	**22.8429**	**1.3344**	**0.2777**	**18.5227**	**0.8742**

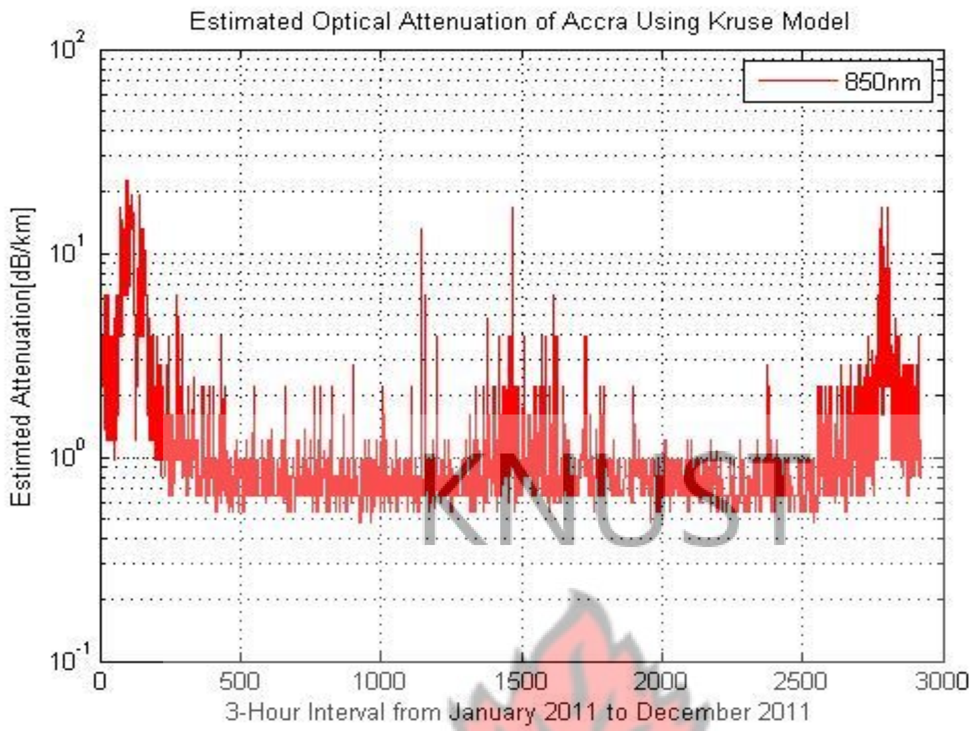

Fig 4.3d Estimated Attenuation coefficient (dB/km) for Accra at 850nm

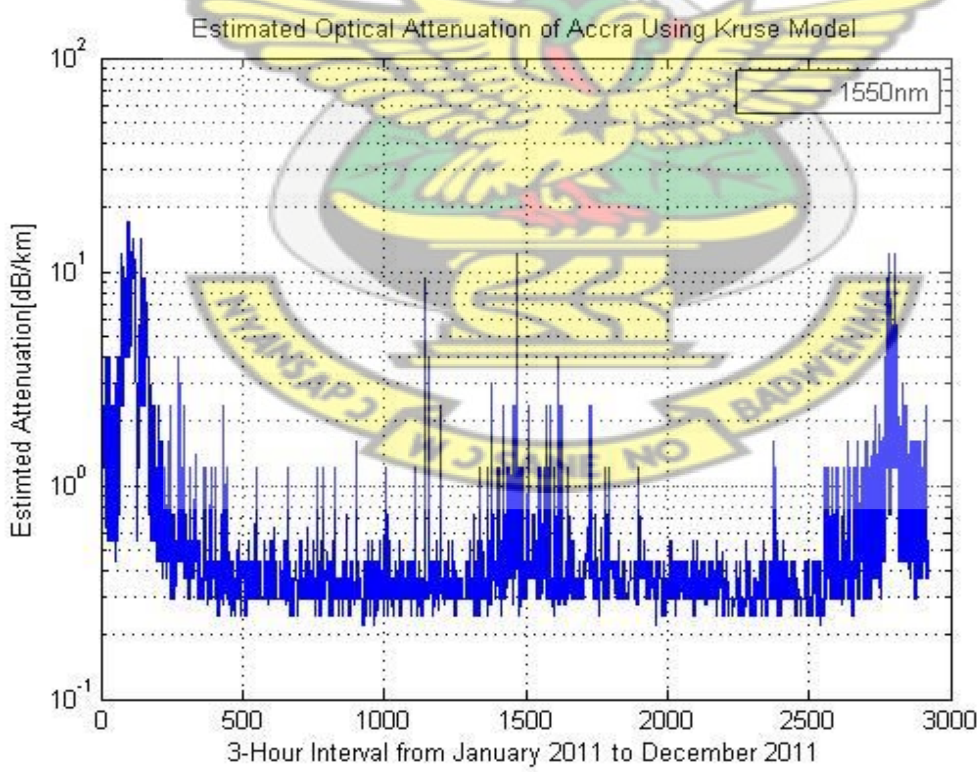

Fig 4.3e Estimated Attenuation coefficient (dB/km) for Accra at 1550nm

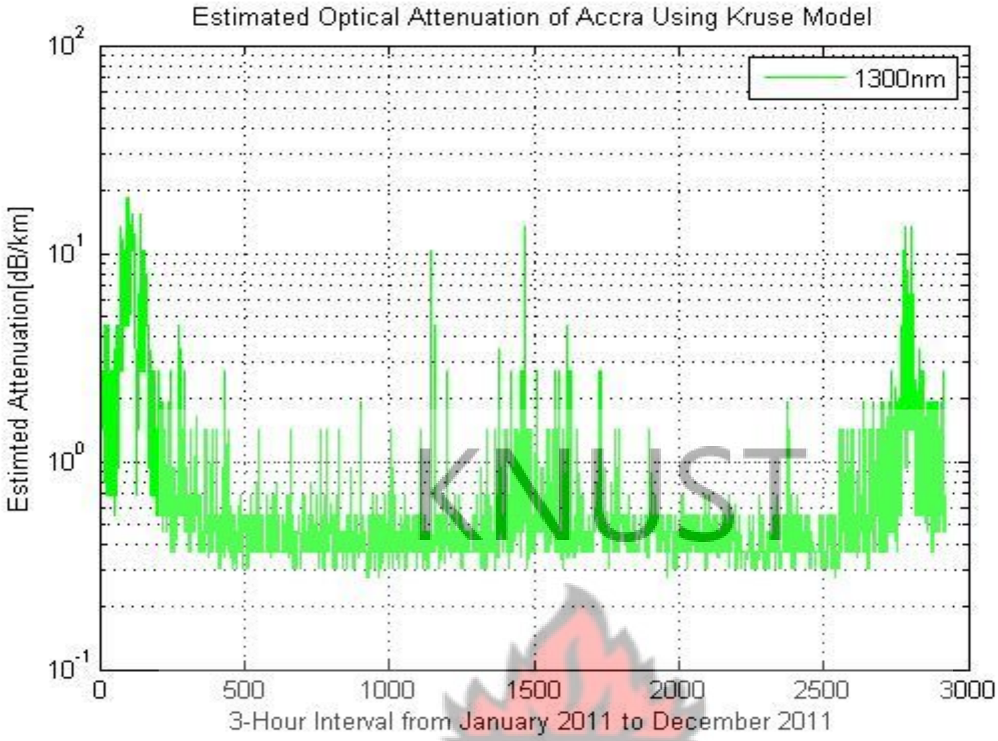

Fig 4.3f Estimated Attenuation coefficient (dB/km) for Accra at 1550nm

The estimated optical attenuation for Bole is shown in figures 4.4a-c for the year 2010. The highest attenuation estimated for the year 2010 was 128.2316dB/km on 1550nm wavelength, 134.5050dB/km on 1300nm and 150.9547dB/km on 850nm wavelength. The lowest estimated attenuation was 0.2209dB/km on 1550nm wavelength, 0.2777dBkm on 1300nm wavelength and 0.4824dB/km on 850nm wavelength. An annual average of 0.9543dB/km on 1550nm wavelength, 1.0844dB/km on 1300nm wavelength and 1.5171dB/km on 850nm were estimated. The results are summarized in table 4.7.

Table 4.7 Summary of Estimated Specific Attenuation of Bole: Year 2010

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.4909	1.6229	0.6890	1.0719	2.8351	1.4725	0.6170	1.9108	0.8602
Feb	0.2209	0.7363	0.4137	0.4824	1.6079	0.9033	0.2777	0.9255	0.5199
Mar	0.2209	128.2316	6.0329	0.4824	150.9547	7.8053	0.2777	134.5050	6.4918
April	0.2454	2.3628	0.3128	0.5360	3.9225	0.6778	0.3085	2.7408	0.3922
May	0.2454	0.7363	0.2891	0.5360	1.6079	0.6314	0.3085	0.9255	0.3634
June	0.2454	3.9583	0.3131	0.5360	6.1633	0.6683	0.3085	4.5062	0.3907
July	0.2325	0.5523	0.2784	0.5078	1.2059	0.6079	0.2923	0.6941	0.3499
Aug	0.24544	37.7434	0.4541	0.5360	47.7555	0.8519	0.3085	40.4350	0.5426
Sept	0.2325	12.0985	0.3443	0.5078	16.7658	0.7117	0.2923	13.3111	0.4249
Oct	0.2209	59.5948	0.5314	0.4824	73.1938	0.9308	0.2777	63.2912	0.6211
Nov	0.2454	37.7434	0.4897	0.5360	47.7555	0.8847	0.3085	40.4350	0.5784
Dec	0.2454	128.2316	1.1749	0.5360	150.9547	1.8992	0.3085	134.5050	1.3401
Annual	**0.2209**	**128.2316**	**0.9543**	**0.4824**	**150.9547**	**1.5171**	**0.2777**	**134.5050**	**1.0844**

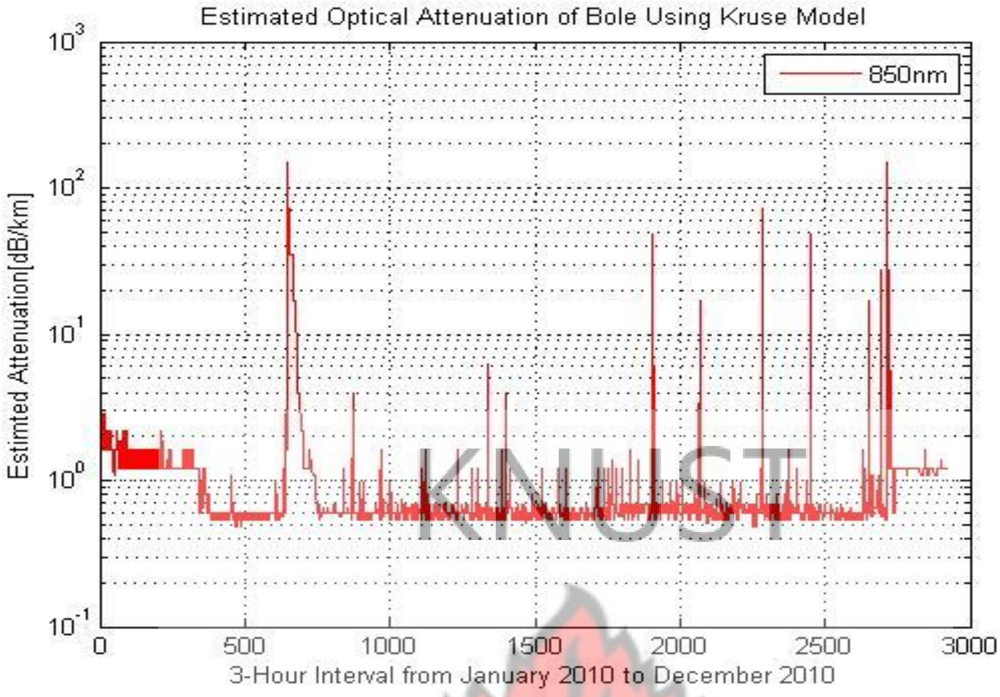

Fig 4.4a Estimated Attenuation coefficient (dB/km) for Bole at 850nm

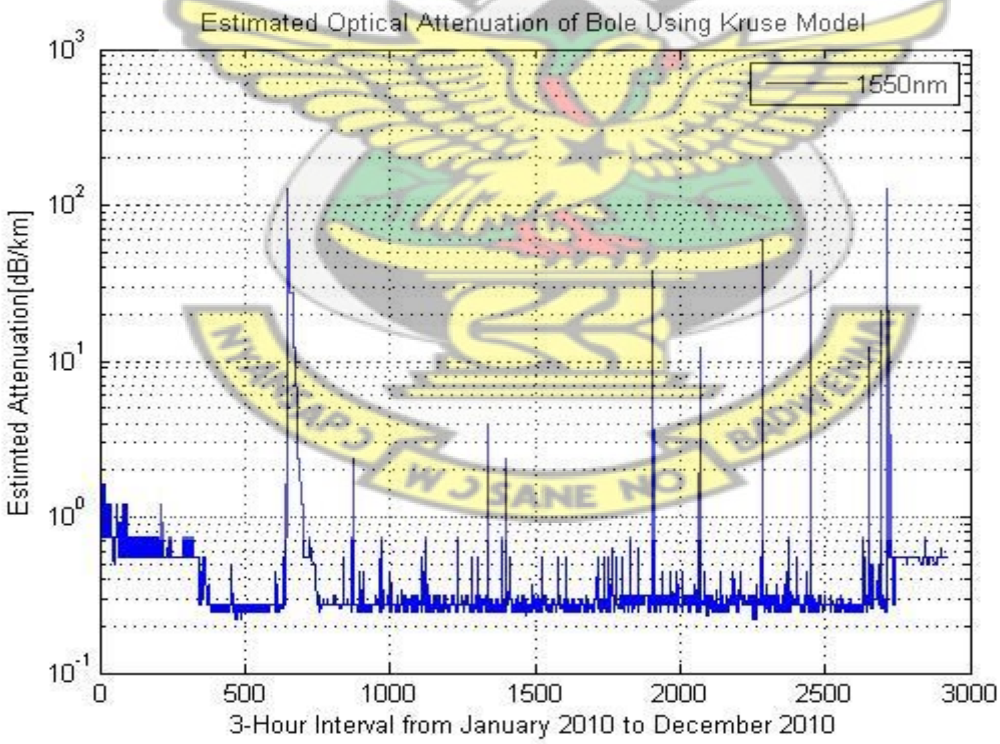

Fig 4.4b Estimated Attenuation coefficient (dB/km) for Bole Year at 1550nm

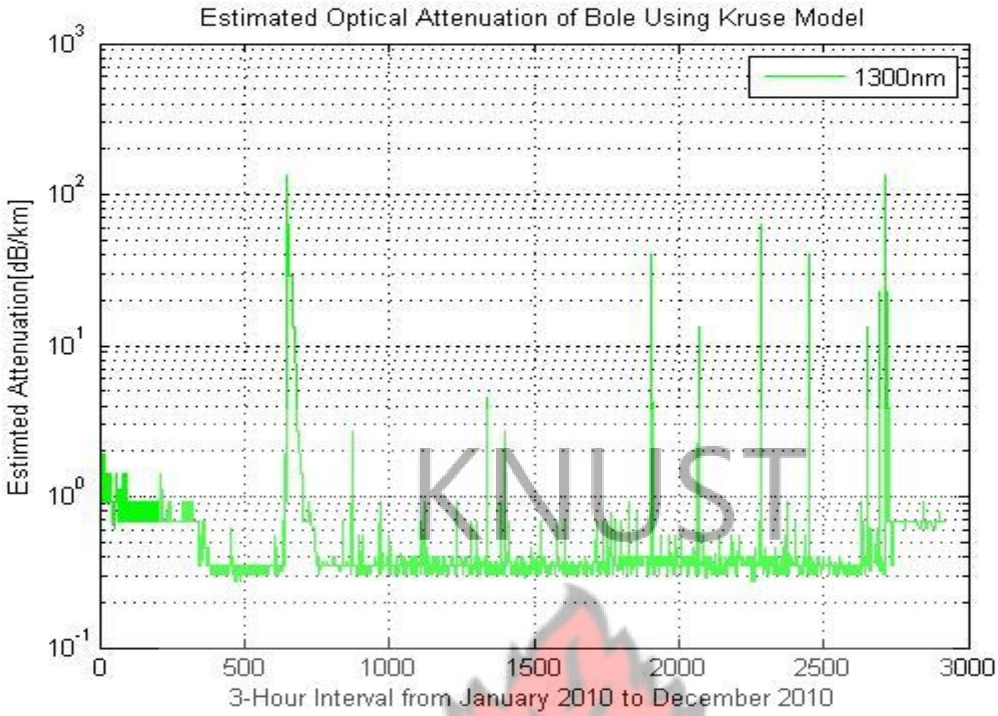

Fig 4.4c Estimated Attenuation coefficient (dB/km) for Bole at 1300nm

The estimated optical attenuation for Bole is shown in figures 4.4d-f for the year 2011. The highest attenuation estimated for the year 2011 was 128.2316dB/km on 1550nm wavelength, 134.5050dB/km on 1300nm wavelength and 150.9547dB/km on 850nm wavelength. The lowest estimated attenuation was 0.1578dB/km on 1550nm wavelength, 0.1983dB/km on 1300nm wavelength and 0.3446dB/km on 850nm wavelength. An annual average of 0.4193dB/km on 1550nm wavelength, 0.5033dB/km on 1300nm wavelength and 0.8339dB/km on 850nm were estimated. Annual averages for the years 2010 and 2011 showed much difference. The results are summarized in table 4.8.

Table 4.8 Summary of Estimated Specific Attenuation of Bole: Year 2011

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.2945	2.3628	0.7149	0.6432	3.9225	1.4697	0.3702	2.7408	0.8820
Feb	0.2209	0.7363	0.4602	0.4824	1.6079	1.0050	0.2777	0.9255	0.5785
Mar	0.2209	0.4418	0.2616	0.4824	0.9647	0.5713	0.2777	0.5553	0.3288
April	0.2209	0.6311	0.2544	0.4824	1.3782	0.5555	0.2777	0.7933	0.3198
May	0.2209	0.5523	0.2610	0.4824	1.2059	0.5700	0.2777	0.6941	0.3281
June	0.2209	12.0985	0.3171	0.4824	16.7658	0.6522	0.2777	13.3111	0.3907
July	0.1578	0.5523	0.2778	0.3446	1.2059	0.6066	0.1983	0.6941	0.3492
Aug	0.2454	128.2316	0.7976	0.5360	150.9547	1.2213	0.3085	134.5050	0.8950
Sept	0.2454	0.5523	0.2822	0.5360	1.2059	0.6162	0.3085	0.6941	0.3547
Oct	0.2209	14.1697	0.3291	0.4824	19.3591	0.6719	0.2777	15.5253	0.4044
Nov	0.2209	0.7363	0.2978	0.4824	1.6079	0.6502	0.2777	0.9255	0.3743
Dec	0.3682	1.6229	0.6594	0.8040	2.8351	1.4056	0.4628	1.9108	0.8226
Annual	**0.1578**	**128.2316**	**0.4103**	**0.3446**	**150.9547**	**0.8339**	**0.1983**	**134.5050**	**0.5033**

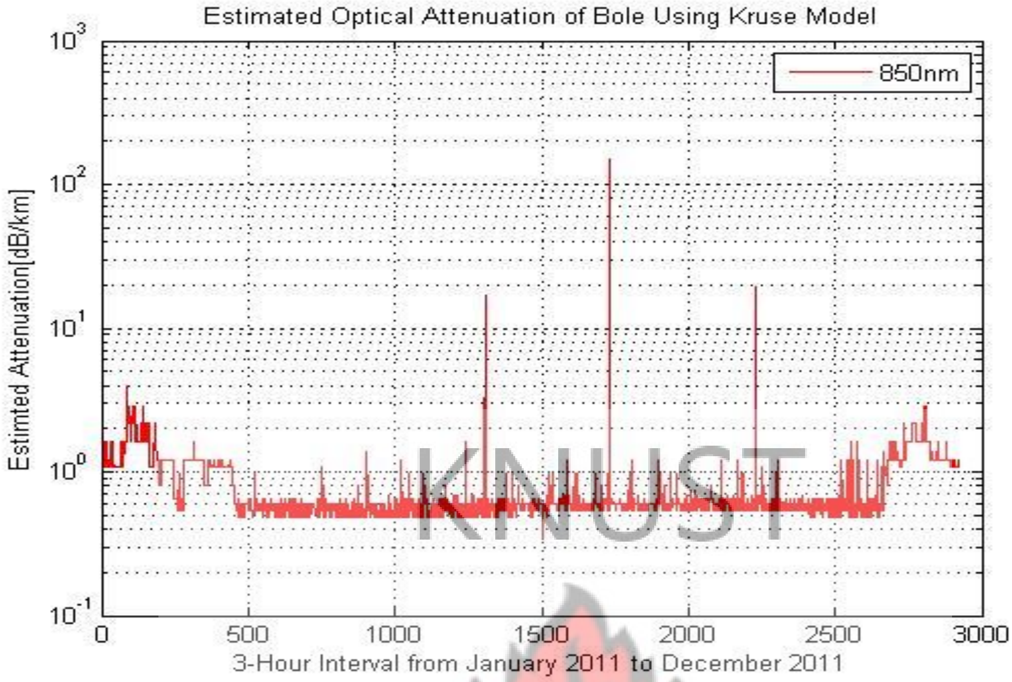

Fig 4.4d Estimated Attenuation coefficient (dB/km) for Bole at 850nm

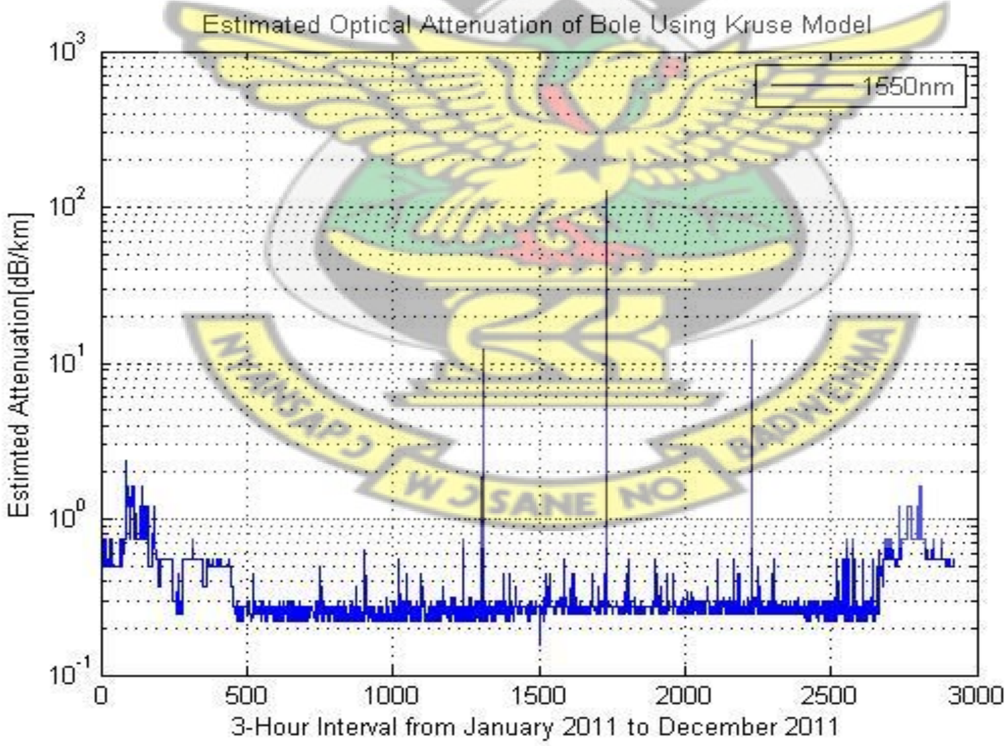

Fig 4.4e Estimated Attenuation coefficient (dB/km) for Bole at 1550nm

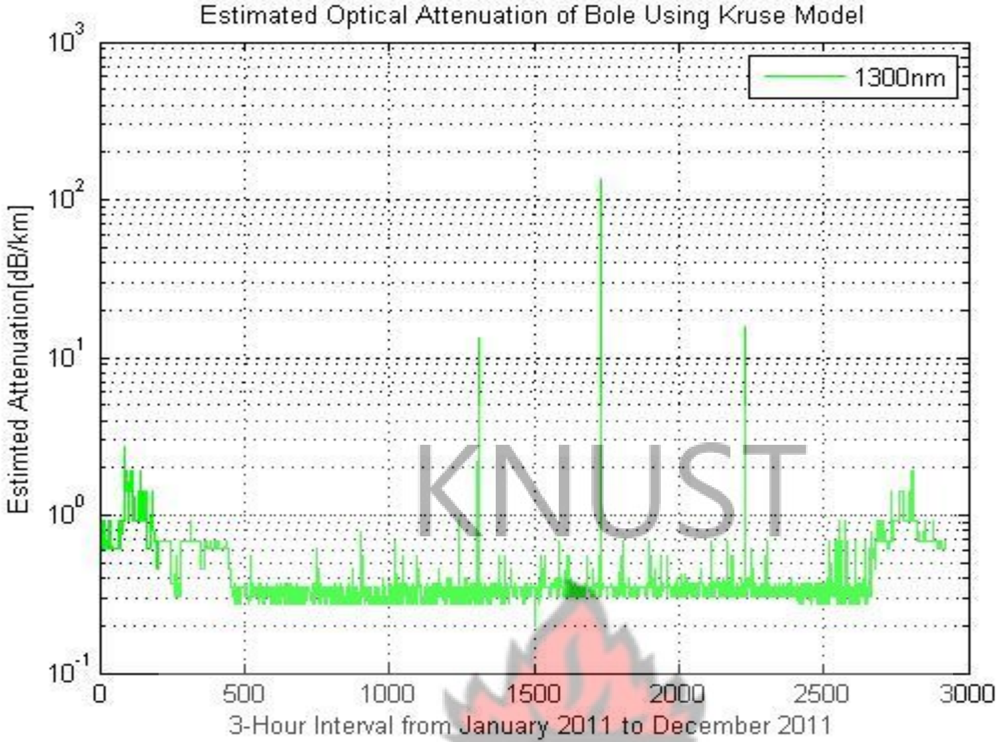

Fig 4.4f Estimated Attenuation coefficient (dB/km) for Bole at 1300nm

The estimated optical attenuation for Kete-Krachi is shown in figures 4.5a-c for the year 2010. The highest attenuation estimated for the year 2010 was 128.2316dB/km on 1550nm wavelength, 134.5050dB/km on 1300nm wavelength and 150.9547dB/km on 850nm wavelength. The lowest estimated attenuation was 0.1473dB/km on 1550nm wavelength, 0.1851dB/km on 1300nm wavelength and 0.3216dB/km on 850nm wavelength. An annual average of 0.4398dB/km on 1550nm wavelength, 0.5528dB/km on 1300nm wavelength and 0.8083dB/km on 850nm wavelength were estimated. The results are summarized in table 4.9.

Table 4.9 Summary of Estimated Specific Attenuation of Kete-Krachi: Year 2010

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Jan	0.1699	128.2316	1.1127	0.3711	150.9547	1.8574	0.2136	134.5050	1.2816
Feb	0.1473	1.2054	0.3876	0.3216	2.1984	0.8367	0.1851	1.4372	0.4855
Mar	0.1473	12.0985	1.6952	0.3216	16.7658	2.6217	0.1851	13.3111	1.9217
April	0.1473	10.5146	0.2725	0.3216	14.7626	0.5610	0.1851	11.6129	0.3359
May	0.1473	0.3682	0.1994	0.3216	0.8040	0.4354	0.1851	0.4628	0.2506
June	0.1473	0.3682	0.2097	0.3216	0.8040	0.4579	0.1851	0.4628	0.2636
July	0.1473	0.3156	0.2040	0.3216	0.6891	0.4454	0.1851	0.3966	0.2564
Aug	0.1578	0.3682	0.2042	0.3446	0.8040	0.4458	0.1983	0.4628	0.2566
Sept	0.1578	0.3156	0.2071	0.3446	0.6891	0.4522	0.1983	0.3966	0.2603
Oct	0.1473	0.3682	0.2077	0.3216	0.8040	0.4535	0.1851	0.4628	0.2610
Nov	0.1578	0.2761	0.2026	0.3446	0.6030	0.4425	0.1983	0.3471	0.2547
Dec	0.1473	27.1750	0.3422	0.3216	35.2074	0.6500	0.1851	29.3154	0.4106
Annual	**0.1473**	**128.2316**	**0.4398**	**0.3216**	**150.9547**	**0.8083**	**0.1851**	**134.5050**	**0.5228**

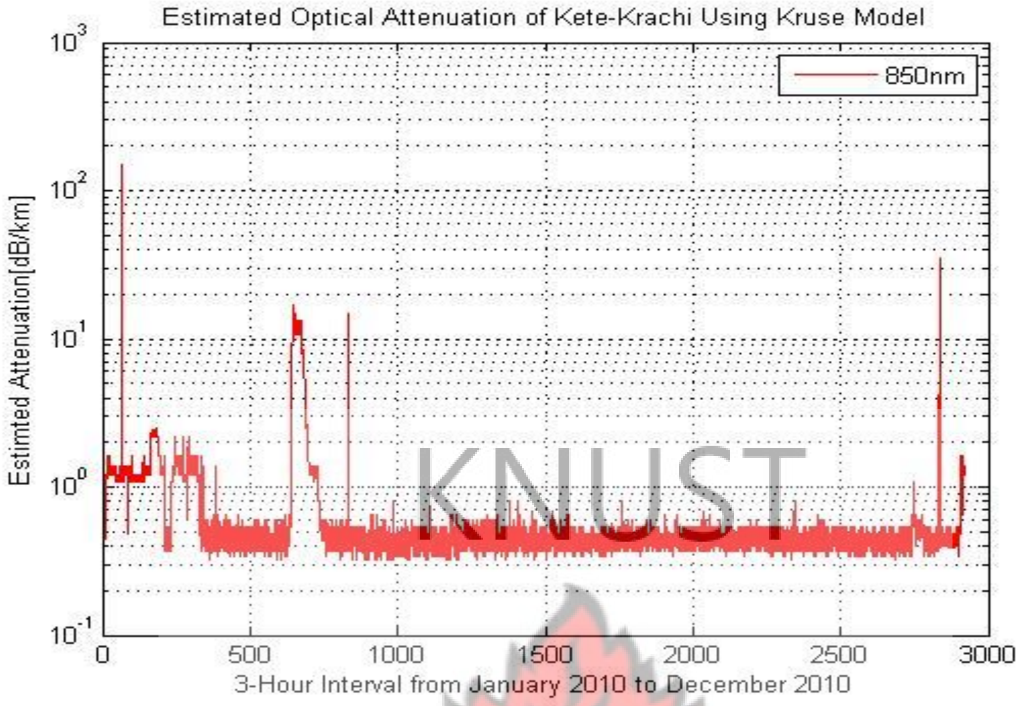

Fig 4.5a Estimated Attenuation coefficient (dB/km) for Kete-Krachi at 850nm

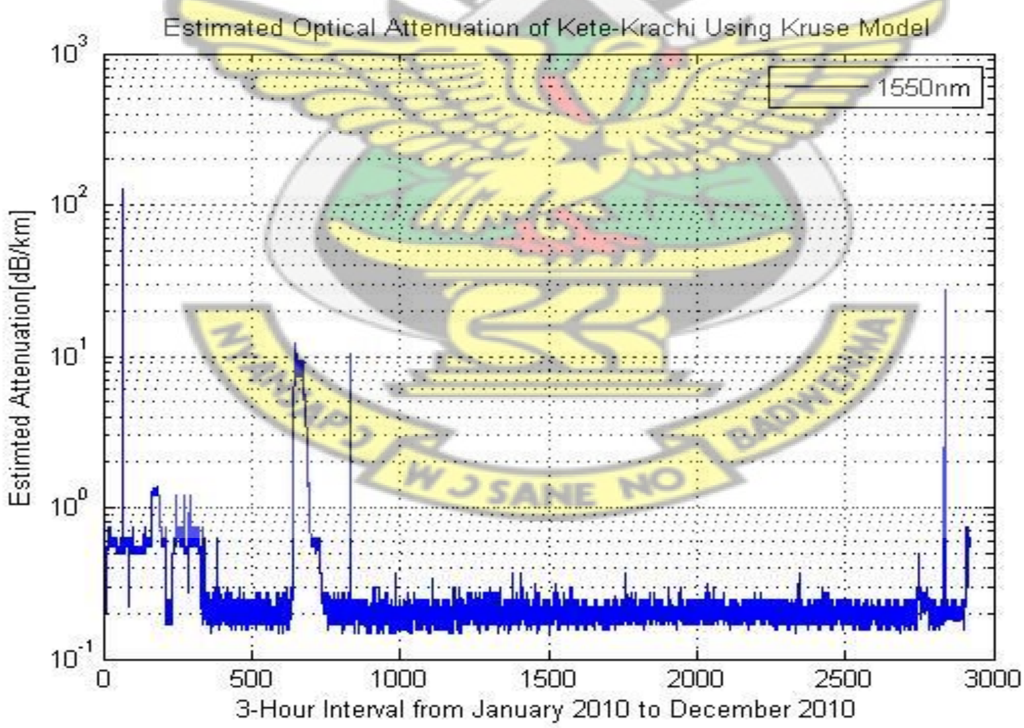

Fig 4.5b Estimated Attenuation coefficient (dB/km) for Kete-Krachi at 1550nm

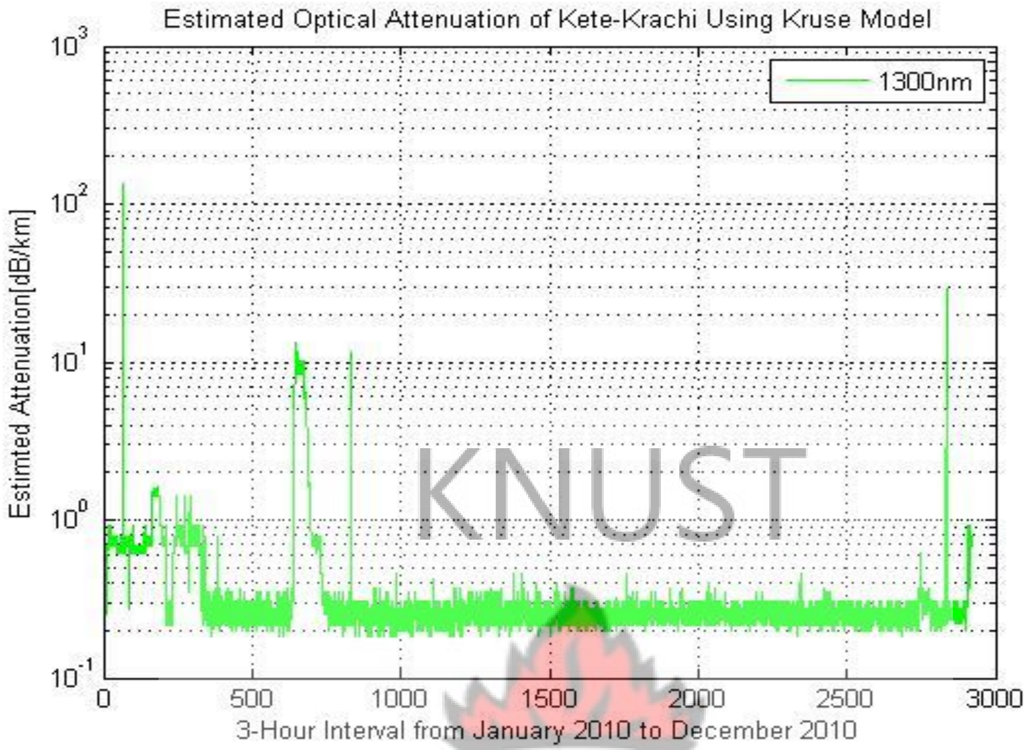

Fig 4.5c Estimated Attenuation coefficient (dB/km) for Kete-Krachi at 1300nm

The estimated optical attenuation for Kete-Krachi is shown in figures 4.5d-f for the year 2011. The highest attenuation estimated for the year 2011 was 16.9829dB/km on 1550nm wavelength, 18.5527dB/km on 1300nm wavelength and 22.8429dB/km on 850nm wavelength. The lowest estimated attenuation was 0.1473dB/km on 1550nm wavelength, 0.1851dB/km on 1300nm wavelength and 0.3216dB/km on 850nm wavelength. An annual average of 0.4015dB/km on 1550nm wavelength, 0.4847dB/km on 1300nm wavelength and 0.7716dB/km on 850nm were estimated. The results are summarized in table 4.10.

Table 4.10 Summary of Estimated Specific Attenuation of Kete-Krachi: Year 2011

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Jan	0.1578	7.4350	1.8924	0.3446	10.8013	3.1096	0.1983	8.2941	2.1852
Feb	0.1578	0.5523	0.2652	0.3446	1.2059	0.5791	0.1983	0.6941	0.3333
Mar	0.1578	0.2761	0.2027	0.3446	0.6030	0.4427	0.1983	0.3471	0.2548
April	0.1473	0.2761	0.2012	0.3216	0.6030	0.4394	0.1851	0.3471	0.2529
May	0.1473	0.3682	0.1981	0.3216	0.8040	0.4326	0.1851	0.4628	0.2490
June	0.1473	0.3682	0.2024	0.3216	0.8040	0.4420	0.1851	0.4628	0.2544
July	0.1578	0.3682	0.2069	0.3446	0.8040	0.4518	0.1983	0.4628	0.2601
Aug	0.1473	0.3682	0.2043	0.3216	0.8040	0.4460	0.1851	0.4628	0.2567
Sept	0.1473	0.3156	0.2006	0.3216	0.6891	0.4381	0.1851	0.3966	0.2522
Oct	0.1473	0.3682	0.2041	0.3216	0.8040	0.4457	0.1851	0.4628	0.2565
Nov	0.1473	0.2945	0.1955	0.3216	0.6432	0.4268	0.1851	0.3702	0.2457
Dec	0.1578	16.9829	0.8058	0.3446	22.8429	1.5388	0.1983	18.5227	0.9714
Annual	**0.1473**	**16.9829**	**0.4015**	**0.3216**	**22.8429**	**0.7712**	**0.1851**	**18.5227**	**0.4847**

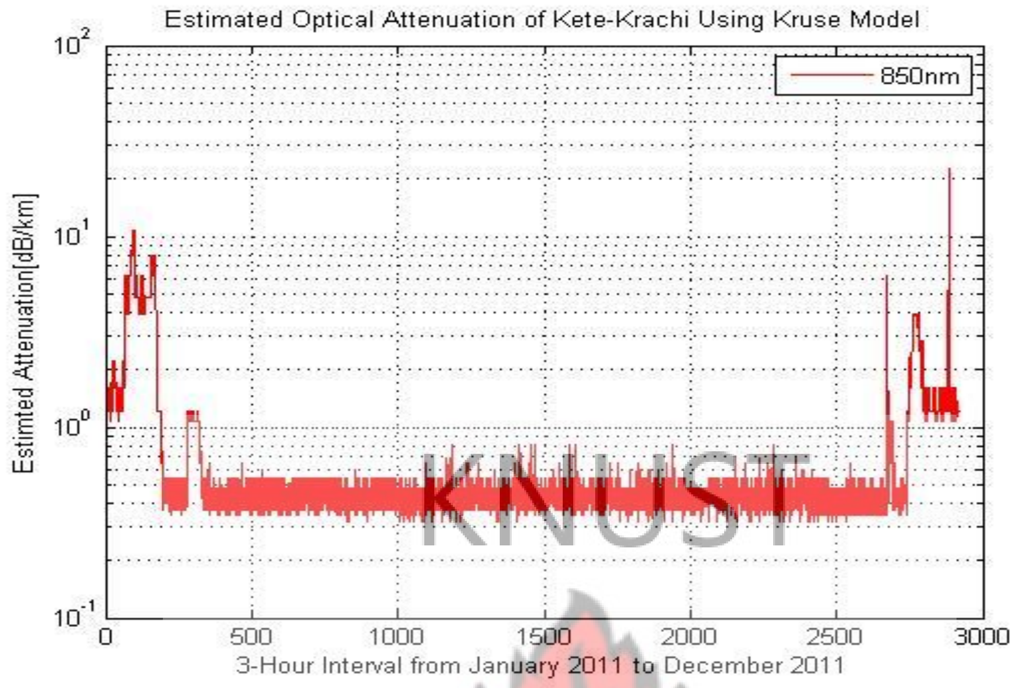

Fig 4.5d Estimated Attenuation coefficient (dB/km) for Kete-Krachi at 850nm

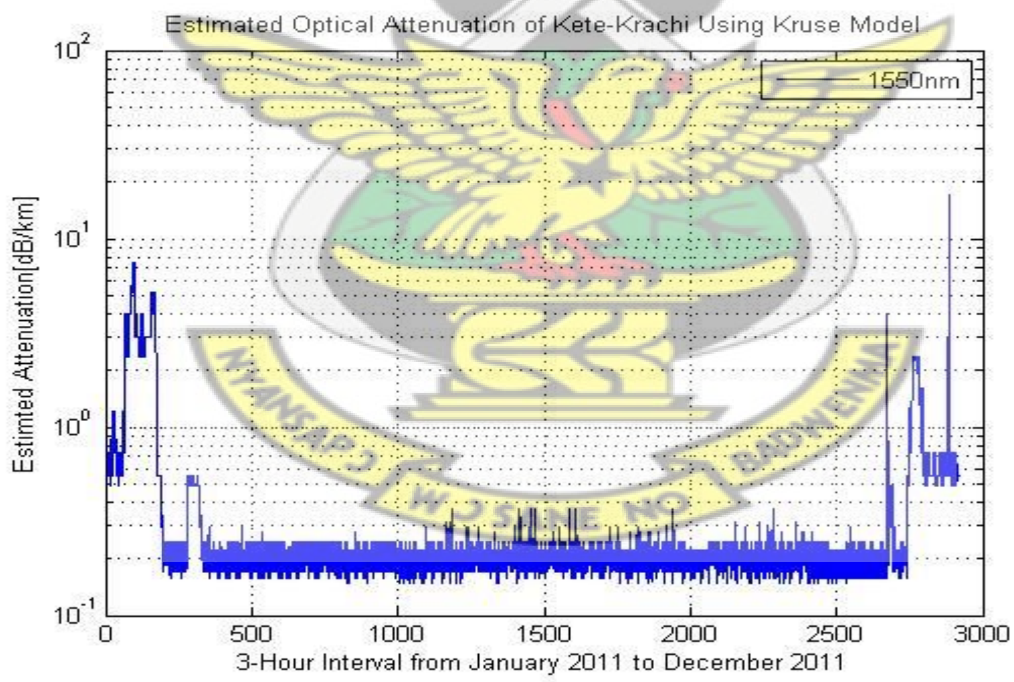

Fig 4.5e Estimated Attenuation coefficient (dB/km) for Kete-Krachi at 1550nm

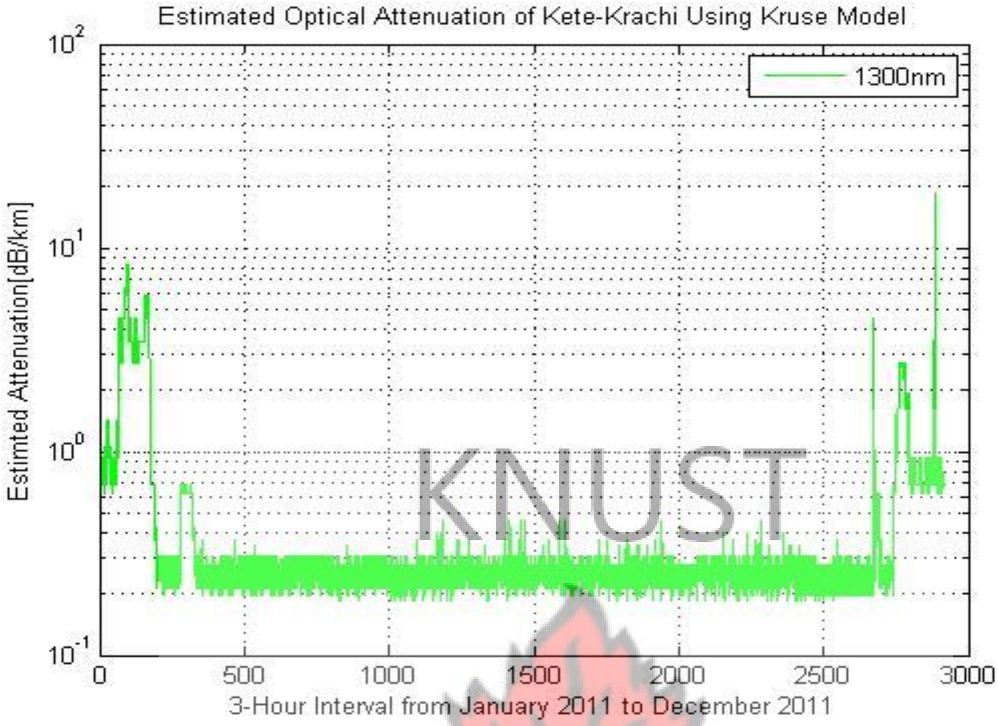

Fig 4.5f Estimated Attenuation coefficient (dB/km) for Kete-Krachi at 1300nm

The estimated optical attenuation for Wa is shown in figures 4.6a-f for the year 2010. The highest attenuation estimated for the year 2010 was 21.0031dB/km on 1550nm wavelength, 22.7904dB/km on 1300nm wavelength and 27.7706dB/km on 850nm wavelength. The lowest estimated attenuation was 0.1578dB/km on 1550nm wavelength, 0.1983dB/km on 1300nm wavelength and 0.3446dB/km on 850nm wavelength. An annual average of 0.7092dB/km on 1550nm wavelength, 0.8374dB/km on 1300nm wavelength and 1.2725dB/km on 850nm were estimated. The results are summarized in table 4.11.

Table 4.11 Summary of Estimated Specific Attenuation of Wa: Year 2010

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.4909	0.7363	0.5508	1.0719	1.6079	1.2028	0.6170	0.9255	0.6923
Feb	0.2945	21.0031	2.4604	0.6432	27.7608	3.7730	0.3702	22.7904	2.7780
Mar	0.3398	12.0985	2.6683	0.7421	16.7658	4.1070	0.4272	13.3111	3.0189
April	0.2945	0.7363	0.3634	0.6432	1.6079	0.7936	0.3702	0.9255	0.4568
May	0.2761	0.5523	0.2906	0.6030	1.2059	0.6346	0.3471	0.6941	0.3653
June	0.2454	0.4418	0.2867	0.5360	0.9647	0.6260	0.3085	0.5553	0.3603
July	0.2209	0.5523	0.2819	0.4824	1.2059	0.6156	0.2777	0.6941	0.3543
Aug	0.1578	0.4418	0.2753	0.3446	0.9647	0.4382	0.1983	0.5553	0.3460
Sept	0.2454	16.9829	0.4009	0.5360	22.8429	0.7867	0.3085	18.5227	0.4865
Oct	0.2454	0.5523	0.2860	0.5360	1.2059	0.6245	0.3085	0.6941	0.3594
Nov	0.2209	0.4418	0.3075	0.4824	0.9647	0.6714	0.2777	0.5553	0.3865
Dec	0.3682	0.5523	0.4601	0.8040	1.2059	1.0046	0.4628	0.6941	0.5783
Annual	**0.1578**	**21.0031**	**0.7092**	**0.3446**	**27.7608**	**1.2725**	**0.1983**	**22.7904**	**0.8374**

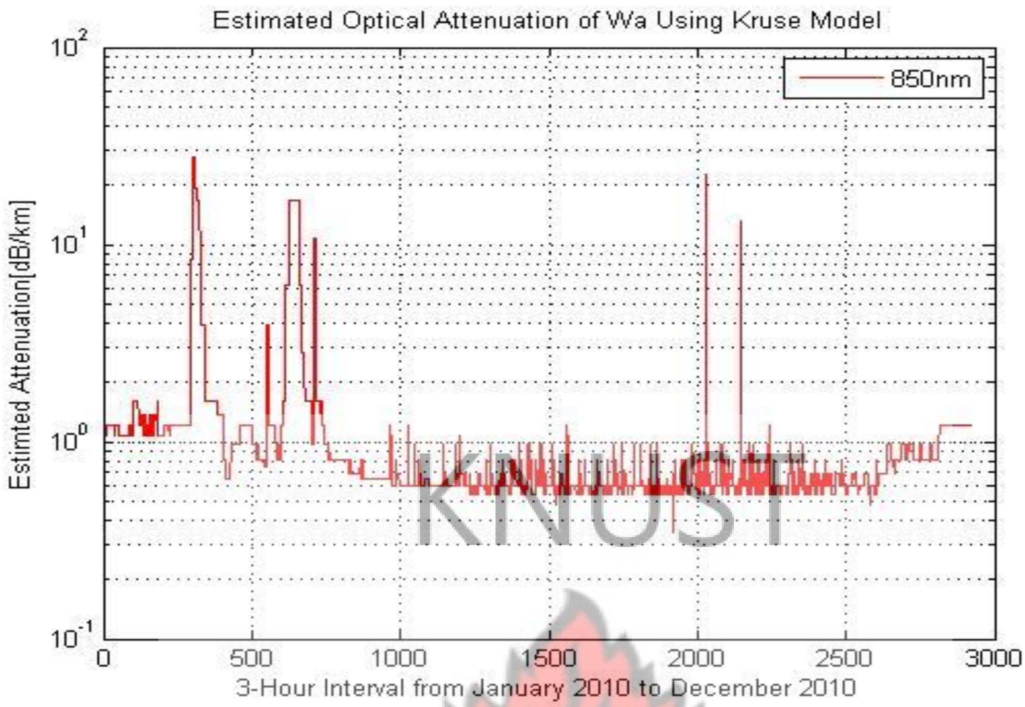

Fig 4.6a Estimated Attenuation coefficient (dB/km) for Wa at 850nm

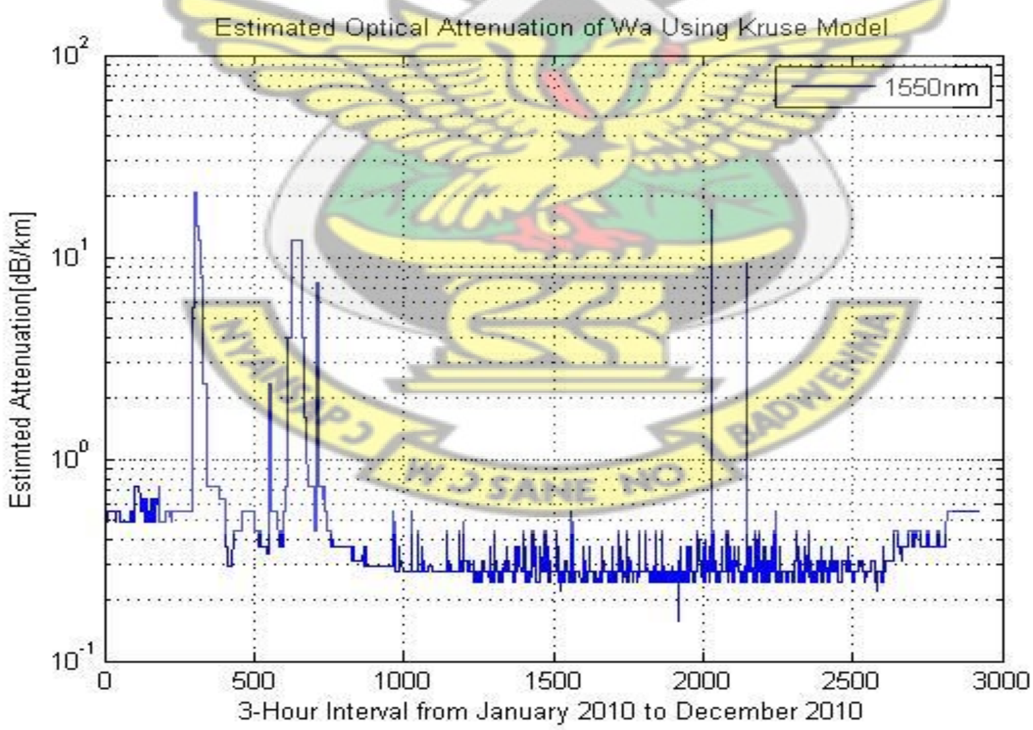

Fig 4.6b Estimated Attenuation coefficient (dB/km) for Wa at 1550nm

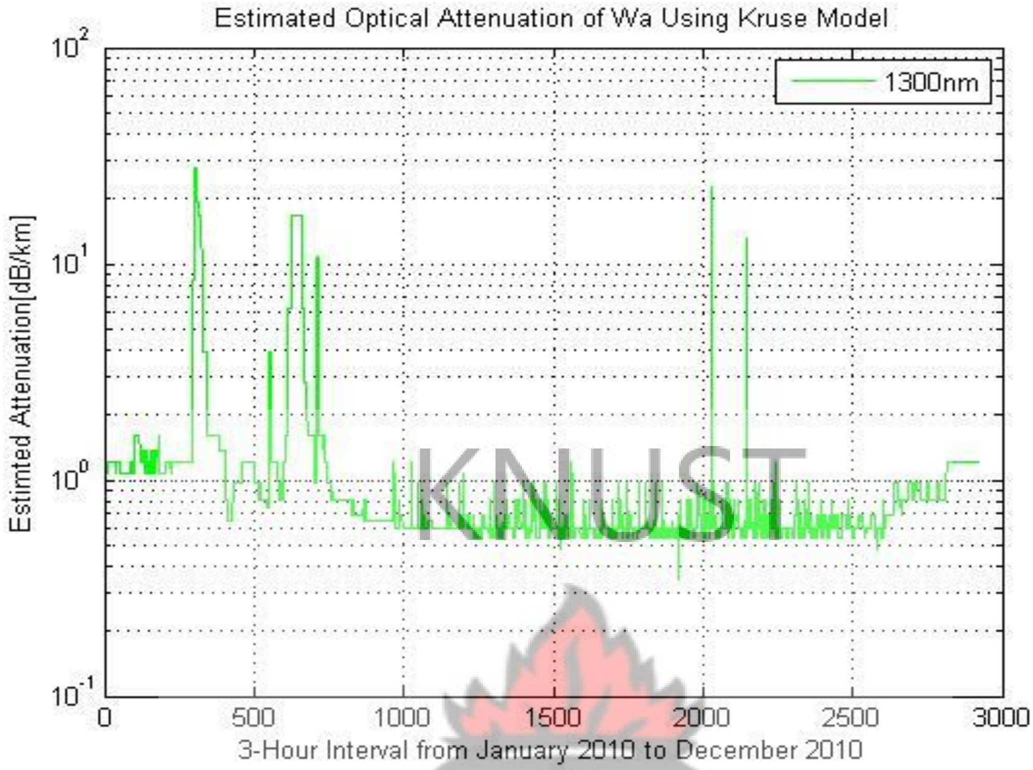

Fig 4.6c Estimated Attenuation coefficient (dB/km) for Wa at 1300nm

The estimated optical attenuation for Wa is shown in figures 4.6d-f for the year 2011. The highest attenuation estimated for the year 2011 was 27.1750dB/km on 1550nm wavelength, 29.3154dB/km on 1300nm wavelength and 35.2074dB/km on 850nm wavelength. The lowest estimated attenuation was 0.2209dB/km on 1550nm wavelength, 0.2777dB/km on 1300nm wavelength and 0.4824dB/km on 850nm wavelength. An annual average of 0.5598dB/km on 1550nm wavelength, 0.7165dB/km on 1300nm wavelength and 1.1143B/km on 850nm were estimated. The results are summarized in table 4.12.

Table 4.12 Summary of Estimated Specific Attenuation of Wa: Year 2011

Month	Attenuation 1550nm [dBkm^{-1}]			Attenuation 850nm [dBkm^{-1}]			Attenuation 1300nm [dBkm^{-1}]		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Jan	0.4909	9.2673	3.2480	1.0719	13.1701	5.0475	0.6170	10.2717	3.6914
Feb	0.3398	1.3881	0.4953	0.7421	2.4796	1.0480	0.4272	1.6451	0.6165
Mar	0.2209	0.4418	0.2898	0.4824	0.9647	0.6328	0.2777	0.5553	0.3642
April	0.2209	0.4418	0.2597	0.4824	0.9647	0.5671	0.2777	0.5553	0.3264
May	0.2209	27.1750	0.3832	0.4824	35.2074	0.7395	0.2777	29.3154	0.4621
June	0.2454	0.4418	0.2757	0.5360	0.9647	0.6021	0.3085	0.5553	0.3466
July	0.2454	0.4418	0.2838	0.5360	0.9647	0.6198	0.3085	0.5553	0.3567
Aug	0.2454	12.0985	0.3428	0.5360	16.7658	0.7079	0.3085	13.3111	0.4229
Sept	0.2454	1.6229	0.2834	0.5360	2.8351	0.6158	0.3085	1.9108	0.3556
Oct	0.2454	0.4418	0.2663	0.5360	0.9647	0.5815	0.3085	0.5553	0.3347
Nov	0.2454	0.5523	0.3448	0.5360	1.2059	0.7529	0.3085	0.6941	0.4334
Dec	0.4909	2.9854	0.6752	1.0719	4.8100	1.3884	0.6170	3.4328	0.8327
Annual	**0.2209**	**27.1750**	**0.5998**	**0.4824**	**35.2074**	**1.1143**	**0.2777**	**29.3154**	**0.7165**

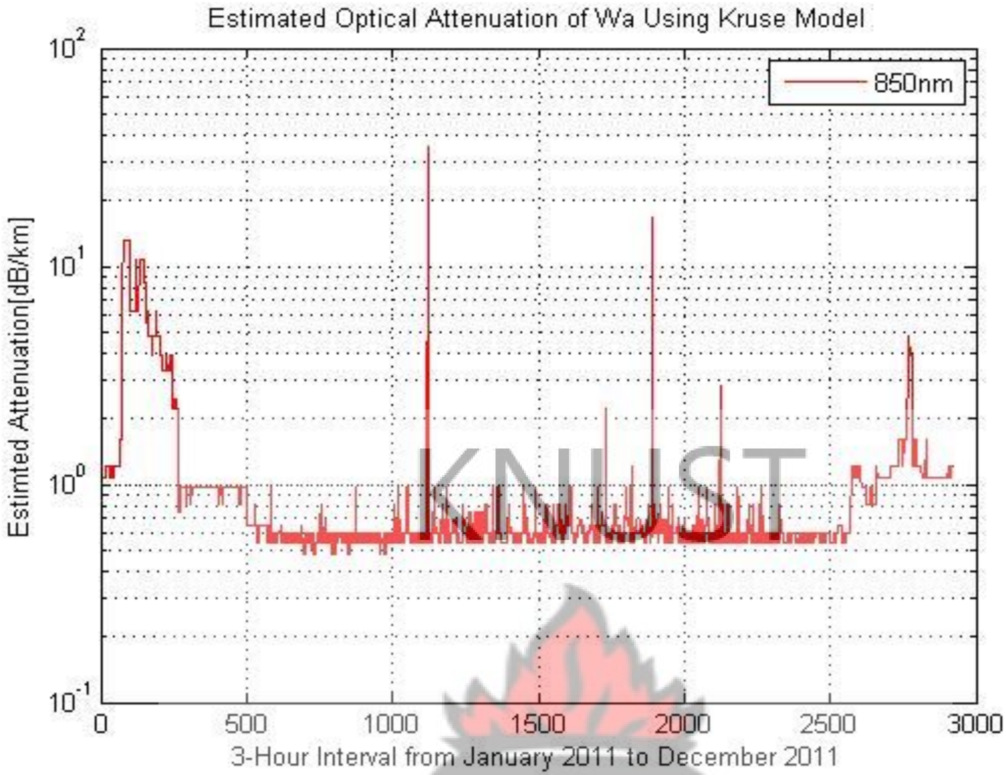

Fig 4.6d Estimated Attenuation coefficient (dB/km) for Wa at 850nm

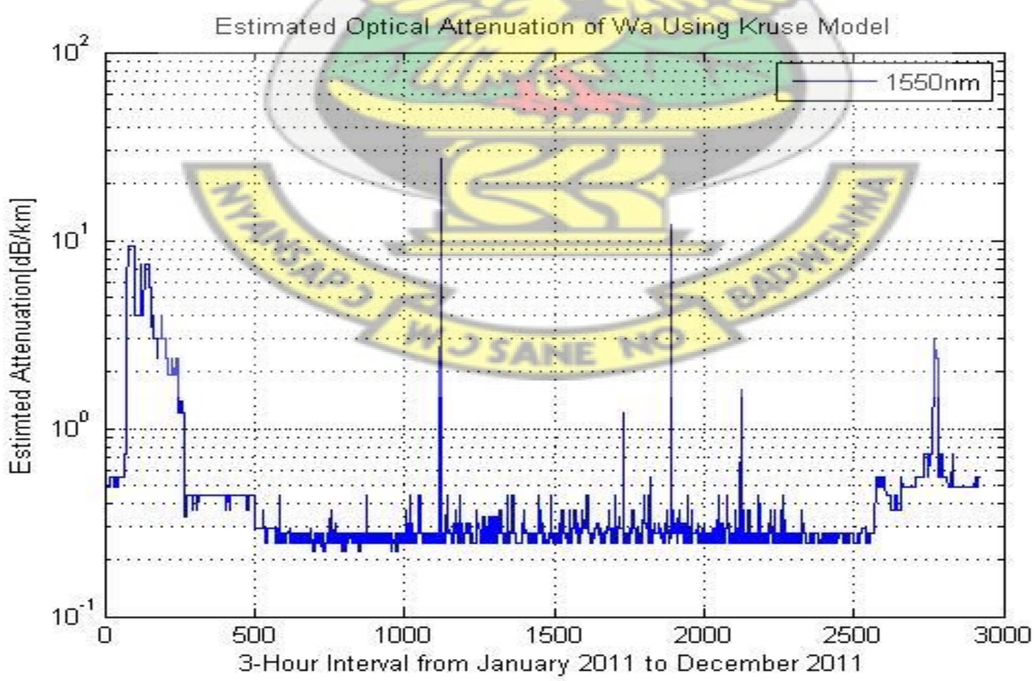

Fig 4.6e Estimated Attenuation coefficient (dB/km) for Wa Year at 1550nm

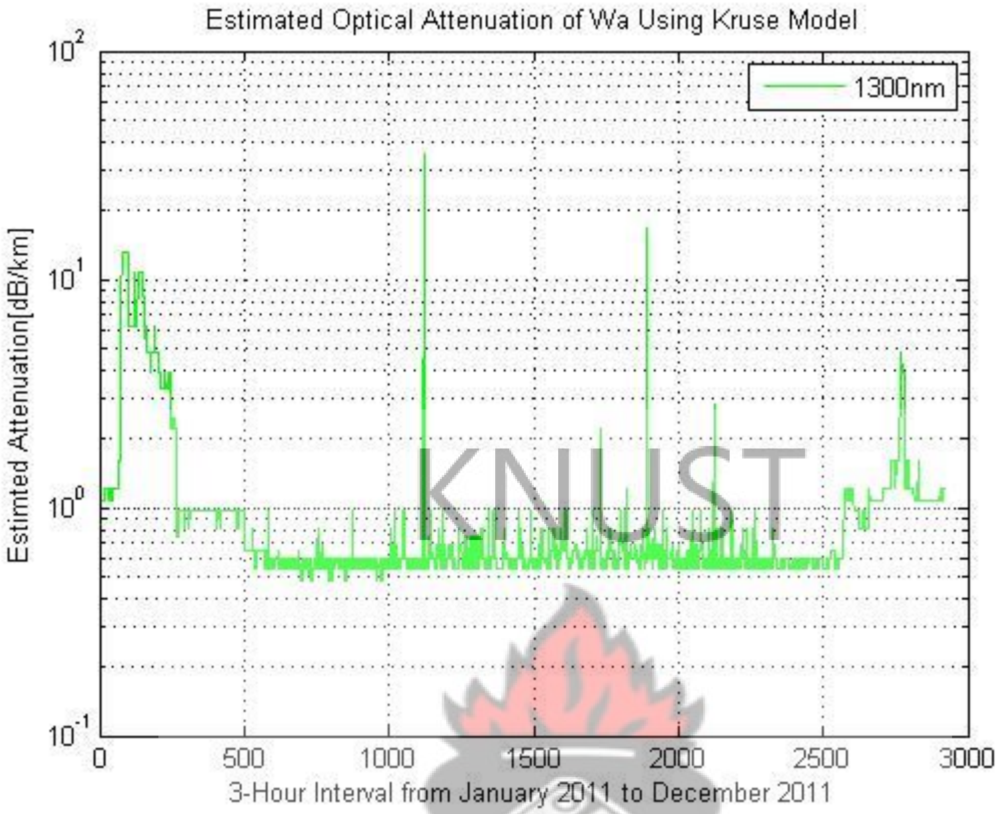

Fig 4.6f Estimated Attenuation coefficient (dB/km) for Wa at 1300nm

Table 4.13 lists the annual averages of all the six cities of Ghana under investigation. The highest attenuation average was estimated in Navrongo whilst the lowest average was estimated in Kete-Krachi. Using 1550nm and 1300nm FSO system, the attenuation averages estimated for all the cities fell below 1dB/km. Attenuation averages fell below 2dB/km on 850nm systems.

Table 4.13 Annual Average of Specific Attenuation of Ghanaian Cities

City	Average Attenuation 1550nm			Average Attenuation 850nm			Average Attenuation 1300nm		
	2010	2011	Average	2010	2011	Average	2010	2011	Average
Kumasi	0.8216	1.0771	**0.9494**	1.4086	1.7310	**1.5698**	0.9564	1.2307	**1.0936**
Navrongo	0.8130	1.0934	**0.9532**	1.4647	1.8008	**1.6328**	0.9607	1.2575	**1.1091**
Accra	0.5134	0.7377	**0.6256**	1.0192	1.3344	**1.1768**	0.6262	0.8742	**0.7502**
Bole	0.9543	0.4103	**0.6823**	1.5171	0.8339	**1.1755**	1.0844	0.5033	**0.7939**
Kete-Krachi	0.4398	0.4015	**0.4207**	0.8083	0.7712	**0.7897**	0.5228	0.4847	**0.5038**
Wa	0.7092	0.5998	**0.6545**	1.2725	1.1143	**1.1934**	0.8374	0.7165	**0.7770**

4.3 Probability of encountering different Atmospheric Attenuation Conditions

We further estimated the probability of exceeding different atmospheric attenuation values in a given area in Ghana. Although in reality the visibility statistics are location dependent and therefore the attenuation conditions are also location dependent, it is important to have an idea of what attenuation will be encountered in a given area at a given time before installation. With knowledge of the probability of exceeding a particular attenuation value, the system installer can predict the system outage probability when the maximum atmospheric attenuation the FSO system can withstand is known. Figures 4.7-4.12 show the probability of encountering different atmospheric conditions. On the X-axis are specific attenuation values. On the Y-axis is the probability that those attenuation values will be exceeded in a given area.

For Kumasi, the figure 4.7 shows the probability of encountering different atmospheric attenuation conditions for 850nm, 1550nm and 1300nm wavelength systems. Using an 850nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.2392 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0175. The probability of encountering attenuation exceeding 20dB/km is 0.0116 whereas the probability of encountering attenuation exceeding the highest attenuation of Kumasi (i.e. 150.95dB/km) is $5.137*10^{-4}$.

Using a 1550nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.1127 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0142. The probability of encountering attenuation exceeding 20dB/km is 0.008 whereas the probability of encountering attenuation exceeding the highest attenuation of Kumasi (i.e. 128.2316dB/km) is $5.137*10^{-4}$.

On a 1300nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.1231 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0103. The probability of encountering attenuation exceeding 20dB/km is 0.0034 whereas the probability of encountering attenuation exceeding the highest attenuation of Kumasi (i.e. 134.5050dB/km) is $1.7123*10^{-4}$.

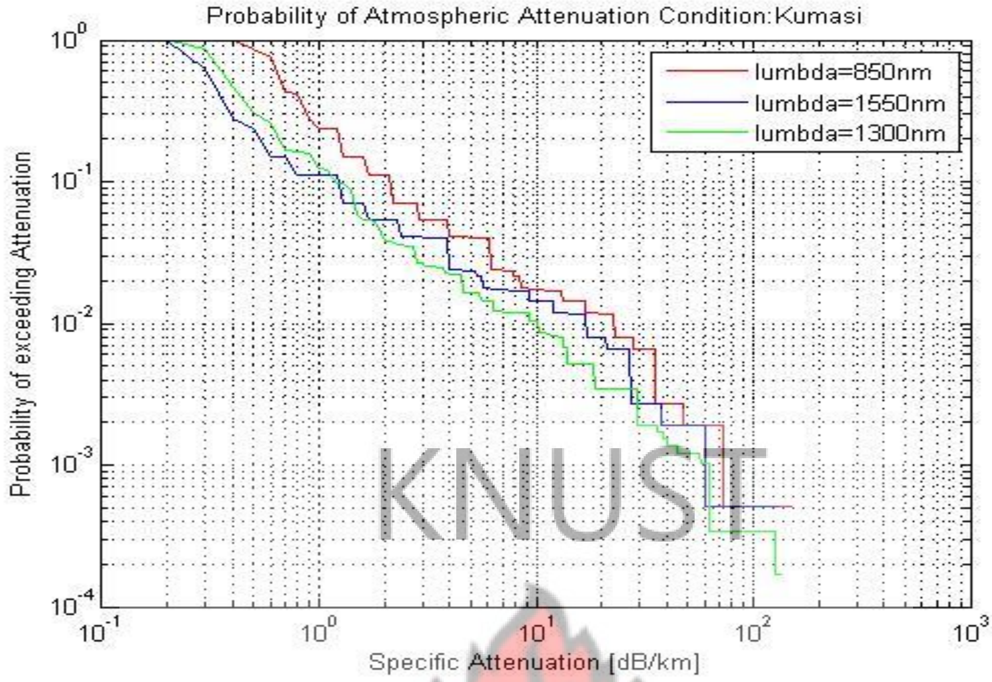

Fig. 4.7 Probability of encountering different Atmospheric Attenuation Conditions: Kumasi

For Navrongo, the figure 4.8 shows the probability of encountering different atmospheric attenuation conditions for 850nm, 1550nm and 1300nm wavelength systems. Using an 850nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.36995 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0209. The probability of encountering attenuation exceeding 20dB/km is 0.0125 whereas the probability of encountering attenuation exceeding the highest attenuation of Navrongo (i.e. 47.75dB/km) is 0.0038.

Using a 1550nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.0807 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0170. The probability of encountering attenuation exceeding 20dB/km is 0.0116 whereas the probability of encountering attenuation exceeding the highest attenuation of Navrongo (i.e. 37.74dB/km) is 0.0038.

On a 1300nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.0807 whereas the probability of encountering attenuation exceeding 10dB/km is

0.0170. The probability of encountering attenuation exceeding 20dB/km is 0.0116 whereas the probability of encountering attenuation exceeding the highest attenuation of Navrongo (i.e. 40.435dB/km) is 0.0038.

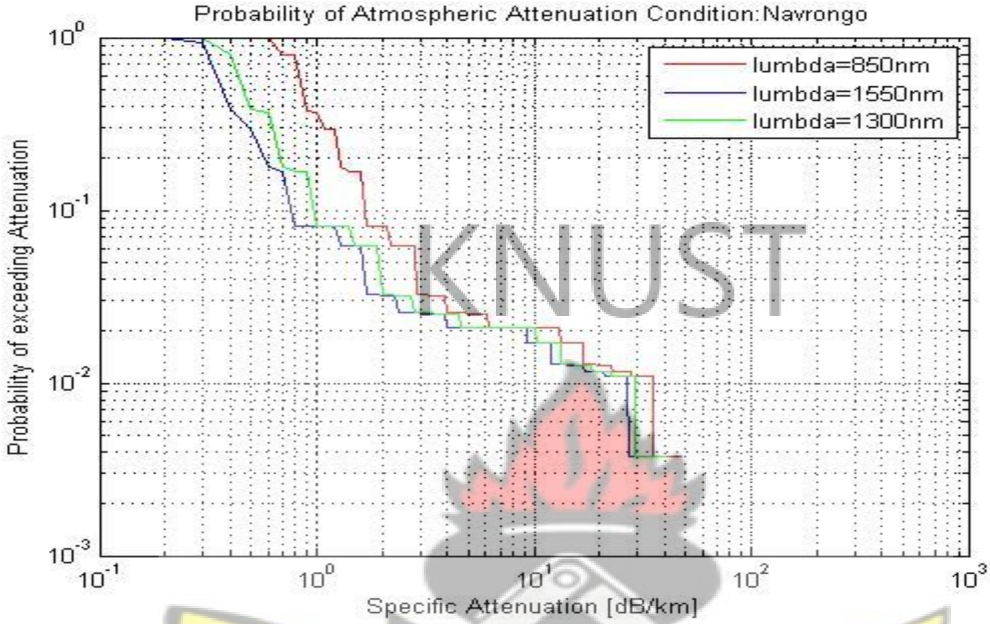

Fig. 4.8 Probability of encountering different Atmospheric Attenuation Conditions: Navrongo

For Accra, the figure 4.9 shows the probability of encountering different atmospheric attenuation conditions for 850nm, 1550nm and 1300nm wavelength systems. Using an 850nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.1601 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0101. The probability of encountering attenuation exceeding 20dB/km is $6.8493*10^{-4}$ whereas the probability of encountering attenuation exceeding the highest attenuation of Accra (i.e. 27.7608dB/km) is $1.7123*10^{-4}$.

Using a 1550nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.1007 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0050. The probability of encountering attenuation exceeding 20dB/km is $1.7123*10^{-4}$ whereas the probability of encountering attenuation exceeding the highest attenuation of Accra (i.e. 21.0031dB/km) is $1.7123*10^{-4}$.

On a 1300nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.1329 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0019. The probability of encountering attenuation exceeding 20dB/km is $1.7123*10^{-4}$ whereas the probability of encountering attenuation exceeding the highest attenuation of Accra (i.e. 22.79dB/km) is $1.7123*10^{-4}$.

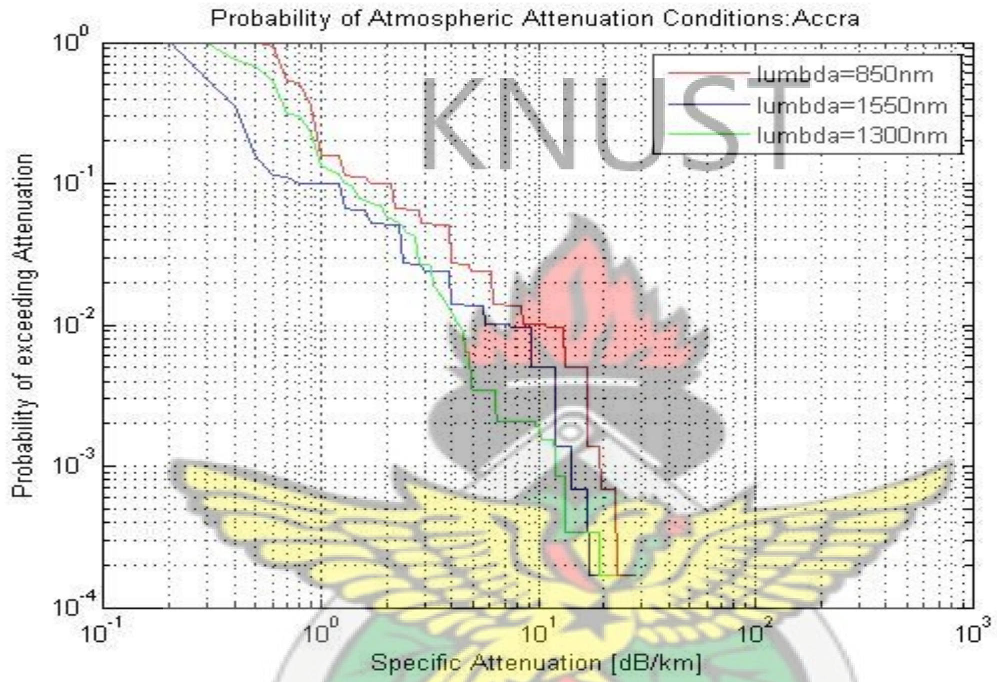

Fig. 4.9 Probability of encountering different Atmospheric Attenuation Conditions: Accra

For Bole, the figure 4.10 shows the probability of encountering different atmospheric attenuation conditions for 850nm, 1550nm and 1300nm wavelength systems. Using an 850nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.2356 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0077. The probability of encountering attenuation exceeding 20dB/km is 0.0053 whereas the probability of encountering the highest attenuation of Bole (i.e. 150.9547dB/km) is 0.0010.

Using a 1550nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.0250 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0077. The probability of encountering attenuation exceeding 20dB/km is 0.0053 whereas the probability of encountering the highest attenuation of Bole (i.e. 128.2316dB/km) is 0.0010.

Using a 1300nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.0250 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0077. The probability of encountering attenuation exceeding 20dB/km is 0.0053 whereas the probability of encountering attenuation exceeding the highest attenuation of Bole (i.e. 134.5050dB/km) is 0.0010.

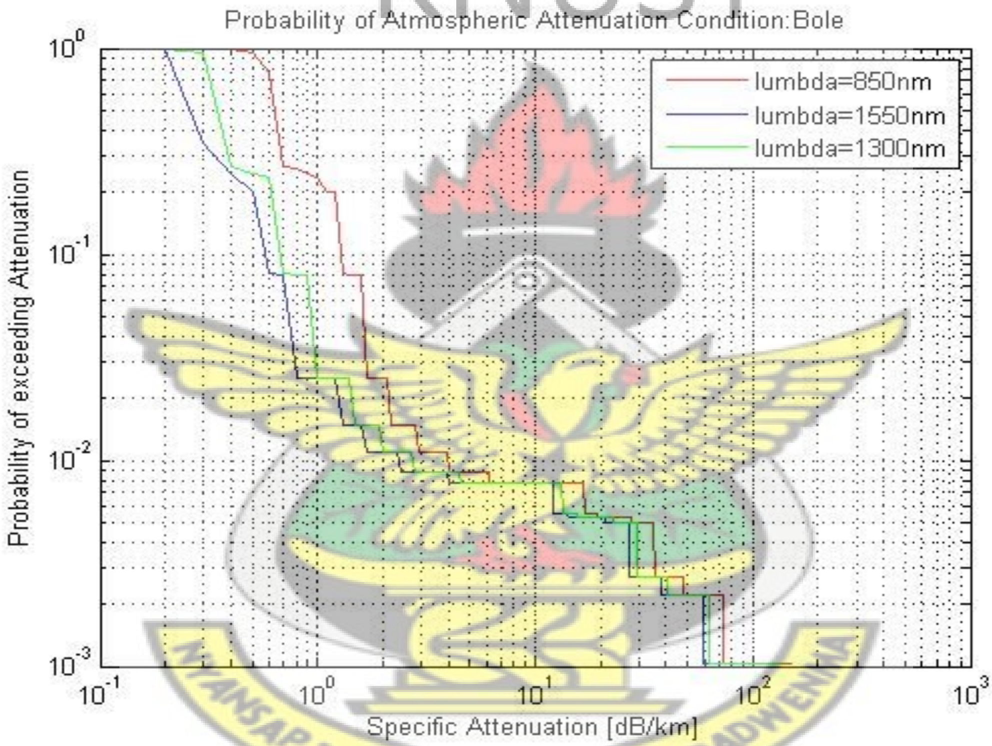

Fig. 4.10 Probability of encountering different Atmospheric Attenuation Conditions: Bole

For Kete-Krachi, the figure 4.11 shows the probability of encountering different atmospheric attenuation conditions for 850nm, 1550nm and 1300nm wavelength systems. Using an 850nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.1414 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0067. The probability of encountering attenuation exceeding 20dB/km is $5.137*10^{-4}$ whereas the probability of encountering attenuation exceeding the highest attenuation of Kete-Krachi (i.e. 150.9547dB/km) is 1.7123*10^{-4}.

Using a 1550nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.0435 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0019. The probability of encountering attenuation exceeding 20dB/km is 3.4247*10^{-4} whereas the probability of encountering attenuation exceeding the highest attenuation of Kete-Krachi (i.e. 128.2316dB/km) is 1.7123*10^{-4}.

On a 1300nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.0428 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0019. The probability of encountering attenuation exceeding 20dB/km is 3.4247*10^{-4} whereas the probability of encountering attenuation exceeding the highest attenuation of Kete-Krachi (i.e. 134.5050dB/km) is 1.7123*10^{-4}.

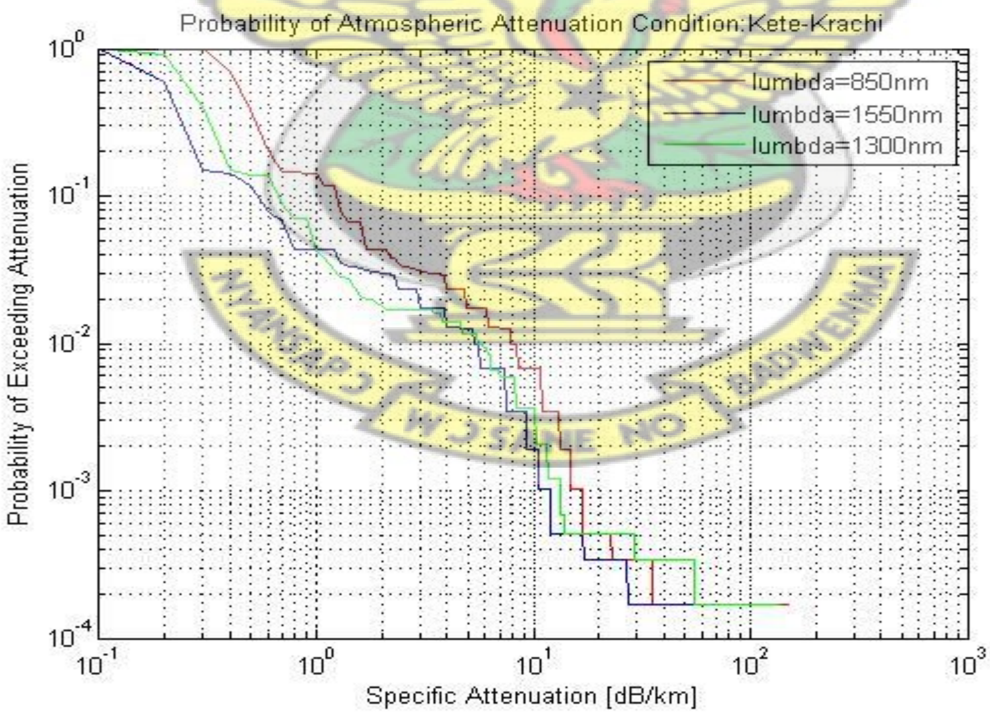

Fig. 4.11 Probability of encountering different Atmospheric Attenuation Conditions: Kete-Krachi

For Wa, the figure 4.12 shows the probability of encountering different atmospheric attenuation conditions for 850nm, 1550nm and 1300nm wavelength systems. Using an 850nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.2231 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0192. The probability of encountering attenuation exceeding 20dB/km is 0.0015 whereas the probability of encountering the highest attenuation of Wa (i.e. 35.2074dB/km) is $1.7123*10^{-4}$.

Using a 1550nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.0577 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0104. The probability of encountering attenuation exceeding 20dB/km is 0.0014 whereas the probability of encountering the highest attenuation of Wa (i.e. 27.1749dB/km) is $1.7123*10^{-4}$.

Using a 1300nm wavelength system, the probability of encountering attenuation exceeding 1dB/km is 0.1185 whereas the probability of encountering attenuation exceeding 10dB/km is 0.0180. The probability of encountering attenuation exceeding 20dB/km is 0.0014 whereas the probability of encountering attenuation exceeding the highest attenuation of Wa (i.e. 29.3154dB/km) is $1.7123*10^{-4}$.

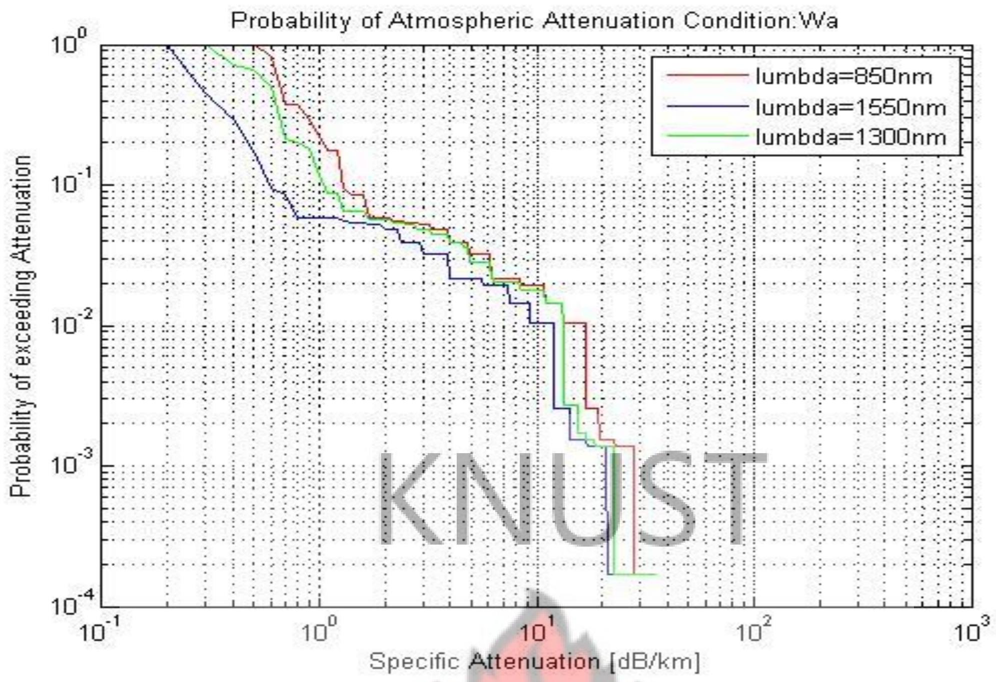

Fig. 4.12 Probability of encountering different Atmospheric Attenuation Conditions: Wa

The tables 4.13-15 summarize the probability of encountering different atmospheric attenuation conditions in Ghana.

Table 4.13 Probability of encountering different Atmospheric Attenuation Conditions (850nm)

City	**Probability of exceeding different Attenuation Values on 850nm wavelength**								
	1dB/km	5dB/km	10dB/km	15dB/km	20dB/km	25dB/km	30dB/km	35dB/km	40dB/km
Kumasi	0.2392	0.0402	0.0175	0.0142	0.0116	0.0080	0.0065	0.0065	0.0027
Navrongo	0.3695	0.0250	0.0209	0.0170	0.0125	0.0116	0.0110	0.0110	0.0038
Accra	0.1601	0.0243	0.0101	0.0050	0.0007	0.0002	0	0	0
Bole	0.2356	0.0087	0.0077	0.0077	0.0053	0.0053	0.0050	0.0050	0.0027
Kete-Krachi	0.1414	0.0175	0.0067	0.0010	0.0005	0.0003	0.0003	0.0003	0.0002
Wa	0.2231	0.0320	0.0192	0.0104	0.0015	0.0014	0.0002	0.0002	0

Table 4.14 Probability of encountering different Atmospheric Attenuation Conditions (1550nm)

City	Probability of exceeding different Attenuation Values on 1550nm wavelength								
	1dB/km	5dB/km	10dB/km	15dB/km	20dB/km	25dB/km	30dB/km	35dB/km	40dB/km
Kumasi	0.1127	0.0236	0.0142	0.0116	0.008	0.0065	0.0027	0.0027	0.0019
Navrongo	0.0807	0.0209	0.0170	0.0125	0.0116	0.0011	0.0038	0.0038	0
Accra	0.1007	0.0137	0.005	0.0007	0.0002	0	0	0	0
Bole	0.0250	0.0077	0.0077	0.0053	0.0053	0.0050	0.0027	0.0027	0.0022
Kete-Krachi	0.0435	0.0127	0.0019	0.0005	0.0003	0.0003	0.0002	0.0002	0.0002
Wa	0.0577	0.0214	0.0104	0.0015	0.0014	0.0002	0	0	0

Table 4.15 Probability of encountering different Atmospheric Attenuation Conditions

City	Probability of exceeding different Attenuation Values on 1300nm wavelength								
	1dB/km	5dB/km	10dB/km	15dB/km	20dB/km	25dB/km	30dB/km	35dB/km	40dB/km
Kumasi	0.1231	0.0164	0.0103	0.0051	0.0034	0.0034	0.0019	0.0019	0.0015
Navrongo	0.0807	0.0209	0.0170	0.0128	0.0116	0.0110	0.0038	0.0038	0.0038
Accra	0.1329	0.0034	0.0019	0.0003	0.0002	0	0	0	0
Bole	0.0250	0.0077	0.0077	0.0055	0.0053	0.0050	0.0027	0.0027	0.0027
Kete-Krachi	0.0428	0.0115	0.0036	0.0005	0.0005	0.0005	0.0003	0.0003	0.0003
Wa	0.1185	0.0283	0.0180	0.0027	0.0014	0.0002	0.0002	0.0002	0

4.4 Fading loss from Scintillation Effects

Figure 4.13 shows the dependence of the fading loss on the power scintillation index for different outage probabilities using equation (29).

The fading loss due to scintillation effects increases as the power scintillation index increases. Therefore the necessary margin needed for particular system outage probability must be allocated to compensate for the fading loss. Again the fading loss increases significantly with increase in the propagation path length. The table 4.16 summarizes the estimated margin needed to compensate for fading loss at allowable system outage probability of 0.001.

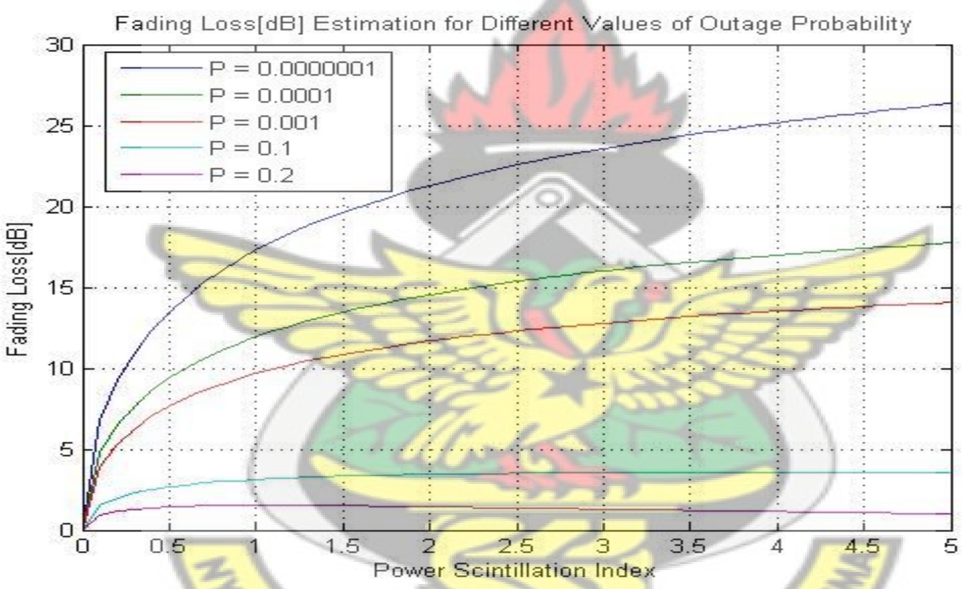

Fig. 4.13 fading loss [dB] for different values of allowed system outage probability

Table 4.16 Margin to compensate for fading loss due to scintillation effects

Link length [km]	**Power Scintillation Index**	**Fading loss [dB]**
1	0.015	1.846
2.5	0.083	3.556
5	0.295	6.305

4.5 Link Budget Analysis

For a typical commercial FSO system whose parameters are specified in the table 3.3, the achievable link range as a function of the link margin for different values of visibility is shown in figure 4.20. The graph is based on equations 8, 29, 39, 41 and 42. By operating the link under consideration at 3.5dB link margin in clear atmosphere with visibility of 20km, two nodes can be reliably connected over a 2km propagation path. Again, by operating the link at 0dB link margin in clear atmosphere with visibility of 20km, link range of about 3km can be achieved.

The link margin can be improved by increasing the transmitted optical power and thereby increasing the achievable link range. Eye/Skin safety standards must be considered when increasing the transmitted optical power.

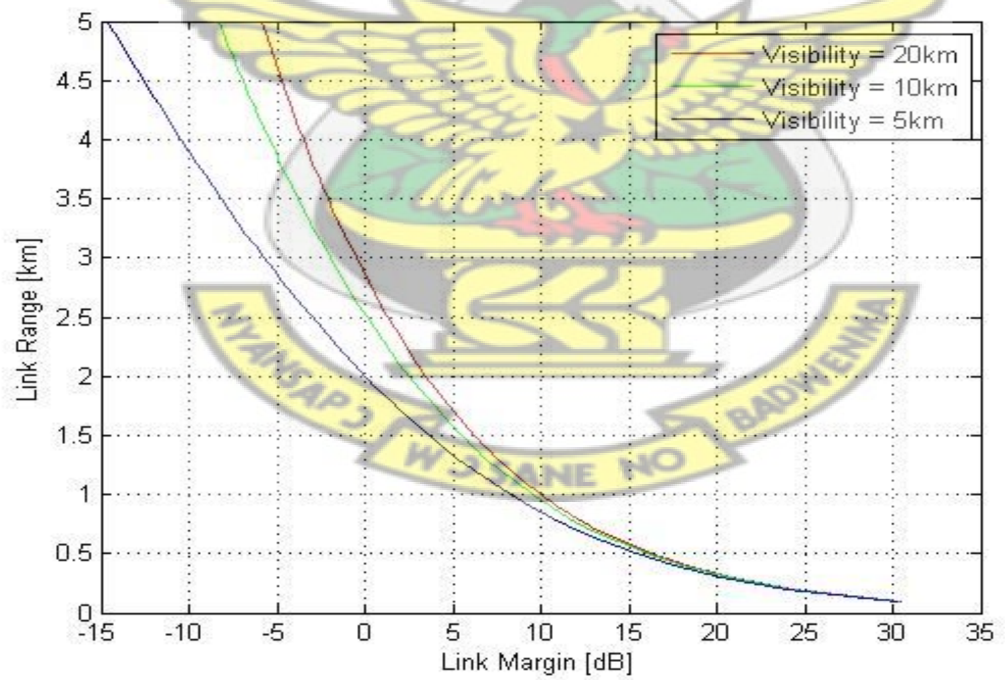

Fig 4.14 Link Range against Link Margin for different values of Visibility

4.6 Availability of FSO in Ghana

An optical link is said to be unavailable if the optical power received is less than the sensitivity of the receiver. The availability of the optical link depends largely on the atmospheric attenuation conditions and it is the main limiting factor in the system availability. The probability that the optical link will be available is the percentage of time during which the power received is greater than or equal to the sensitivity of the receiver. Using equations (41) and (43), we have estimated the availability of the optical link in Kumasi, Navrongo, Accra, Bole, Kete-Krachi and Wa for propagation paths of 1km, 5km and 10km. We took into consideration the estimated specific attenuation of each of the six cities. The system availability estimation for all cities is shown in table 4.17. The system availability decreases with increase in propagation path length.

Table 4.17 FSO System Availability Estimation in Ghana

City	Availability[%] at 1km link range	Availability [%] at 5km link range	Availability[%] at 10km link range
Kumasi	99.726	94.6747	76.0788
Navrongo	99.6233	96.7980	70.2398
Accra	100	94.8801	84.0411
Bole	99.7261	98.9042	80.0856
Kete-Krachi	99.9829	96.9863	88.2021
Wa	100	95.1199	82.5343

4.7 Summary

In this chapter, we discussed the results of the investigation conducted on FSO communication implementation in Ghana. The margin to compensate for losses due to scintillation effects is discussed. The margin to compensate for fading loss due to scintillation must take into consideration the allowable system outage probability. The FSO system availability is estimated for all six Ghanaian cities under research. The system availability decreases with increase in the propagation path length.

Chapter 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this thesis, we have investigated the feasibility of reliable Free Space Optical Communication in Ghana. Atmospheric specific attenuation due to aerosol scattering and the probability of encountering such attenuation values have been estimated in six major cities in Ghana (i.e. Kumasi, Navrongo, Bole, Accra, Kete-Krachi and Wa). The Kruse model has been used on 850nm wavelength, 1300nm wavelength and 1550nm wavelength systems. Effect of scintillation on optical signals has been investigated and the necessary margin to compensate for such losses has been derived. We have further estimated the availability of FSO link in all the six Ghanaian cities.

In Kumasi, the highest attenuation estimated was 128.2316dB/km using 1550nm wavelength system, 134.5050dB/km on 1300nm wavelength system and 150.9547dB/km on 850nm wavelength system. The lowest attenuation estimated was 0.1105dB/km on 1550nm wavelength, 0.1388dB/km on 1300nm wavelength and 0.2412dB/km on 850nm wavelength. The average attenuation estimated was 0.9494dB/km on 1550nm wavelength, 1.0936dB/km on 1300nm wavelength and 1.5698dB/km on 850nm wavelength.

In Navrongo, the highest attenuation estimated was 37.7434dB/km using 1550nm wavelength system, 40.4350dB/km on 1300nm wavelength system and 47.7555dB/km on 850nm wavelength system. The lowest attenuation estimated was 0.2454dB/km on 1550nm wavelength, 0.3085dB/km on 1300nm wavelength and 0.5360dB/km on 850nm wavelength. The average attenuation estimated was 0.9532dB/km on 1550nm wavelength, 1.1091dB/km on 1300nm wavelength and 1.6328dB/km on 850nm wavelength.

In Accra, the highest attenuation estimated was 21.0031dB/km using 1550nm wavelength system, 22.7904dB/km on 1300nm wavelength system and 27.7608dB/km on 850nm wavelength system. The lowest attenuation estimated was 0.2209dB/km on 1550nm wavelength, 0.2777dB/km on 1300nm wavelength and 0.4824dB/km on 850nm wavelength. The average attenuation estimated was 0.6256dB/km on 1550nm wavelength, 0.7502dB/km and 1.1768dB/km on 850nm wavelength.

In Bole, the highest attenuation estimated was 128.2316dB/km using 1550nm wavelength system, 134.5050dB/km on 1300nm wavelength system and 150.9547dB/km on 850nm wavelength system. The lowest attenuation estimated was 0.1578dB/km on 1550nm wavelength, 0.1983dB/km on 1300nm wavelength and 0.3446dB/km on 850nm wavelength. The average attenuation estimated was 0.6823dB/km on 1550nm wavelength, 0.7939dB/km on 1300nm wavelength and 1.1755dB/km on 850nm wavelength.

In Kete-Krachi, the highest attenuation estimated was 128.2316dB/km using 1550nm wavelength system, 134.5050dB/km on 1300nm wavelength system and 150.9547dB/km on 850nm wavelength system. The lowest attenuation estimated was 0.1473dB/km on 1550nm wavelength, 0.1851dB/km on 1300nm wavelength and 0.3216dB/km on 850nm wavelength. The average attenuation estimated was 0.4207dB/km on 1550nm wavelength, 0.5038dB/km on 1300nm wavelength and 0.7897dB/km on 850nm wavelength.

In Wa, the highest attenuation estimated was 27.1750dB/km using 1550nm wavelength system, 29.3154dB/km on 1300nm wavelength system and 35.2074dB/km on 850nm wavelength system. The lowest attenuation estimated was 0.1578dB/km on 1550nm wavelength, 0.1983dB/km on 1300nm wavelength and 0.3446dB/km on 850nm wavelength. The average attenuation estimated was 0.6545dB/km on 1550nm wavelength, 0.7770dB/km on 1300nm wavelength and 1.1934dB/km on 850nm wavelength.

Again, we have investigated the probability of encountering different atmospheric attenuation conditions in Ghana. We have observed that the probability of encountering higher atmospheric attenuation conditions in Ghana is very low.

In Kumasi, the probability that specific attenuation exceeded 5dB/km on 1550nm wavelength system was estimated at 0.0236, 0.0164 on 1300nm wavelength and 0.0402 on 850nm wavelength system. The probability that specific attenuation exceeded 10dB/km on 1550nm wavelength system was estimated at 0.0142, 0.0103 on 1300nm wavelength system and 0.0175 on 850nm wavelength system.

In Navrongo, the probability that specific attenuation exceeded 5dB/km on 1550nm wavelength system was estimated at 0.0209, 0.0209 on 1300nm wavelength and 0.0250 on 850nm wavelength system. The probability that specific attenuation exceeded 10dB/km on 1550nm wavelength system was estimated at 0.0170, 0.0170 on 1300nm wavelength system and 0.0209 on 850nm wavelength system.

In Accra, the probability that specific attenuation exceeded 5dB/km on 1550nm wavelength system was estimated at 0.0137, 0.0034 on 1300nm wavelength system and 0.0243 on 850nm wavelength system. The probability that specific attenuation exceeded 10dB/km on 1550nm wavelength system was estimated at 0.0050, 0.0019 on 1300nm wavelength system and 0.0101 on 850nm wavelength system.

In Bole, the probability that specific attenuation exceeded 5dB/km on 1550nm wavelength system was estimated at 0.0077, 0.0077 on 1300nm wavelength system and 0.0087 on 850nm wavelength system. The probability that specific attenuation exceeded 10dB/km on 1550nm wavelength system was estimated at 0.0053, 0.0077 on 1300nm wavelength system and 0.0077 on 850nm wavelength system.

In Kete-Krachi, the probability that specific attenuation exceeded 5dB/km on 1550nm wavelength system was estimated at 0.0127, 0.0115 on 1300nm wavelength system and

0.0175 on 850nm wavelength system. The probability that specific attenuation exceeded 10dB/km on 1550nm wavelength system was estimated at 0.0019, 0.0036 on 1300nm wavelength system, and 0.0067 on 850nm wavelength system.

In Wa, the probability that specific attenuation exceeded 5dB/km on 1550nm wavelength system was estimated at 0.0214, 0.0283 on 1300nm wavelength system and 0.0320 on 850nm wavelength system. The probability that specific attenuation exceeded 10dB/km on 1550nm wavelength system was estimated at 0.0104, 0.0180 on 1300nm wavelength system and 0.0192 on 850nm wavelength system.

Furthermore, we have investigated the effects of scintillation on optical signals using the lognormal statistical model. We have shown that the fading loss due to scintillation effects depends on the power scintillation index. The margin to compensate for scintillation effects must take into consideration the allowable system outage probability. As the power scintillation index increases, the fading loss also increases. The power scintillation index increases with increase in propagation path length and the refractive index profile. The margin to compensate for such fading loss increases with decrease in allowable system outage probability. Thus for a higher reliable link, more margin must be included to compensate for fading loss due to scintillation.

Lastly, we have performed link budget analysis and investigated the availability of Free Space Optical Communication systems in Ghana. We have used the specifications of commercial FSO systems in the link budget analysis. The importance of the link budget analysis is to ascertain the achievable link range for different link margin and receiver sensitivity. We have shown that the achievable link range increases with increase in atmospheric visibility conditions. The link range can be increased by also increasing the transmitted optical power. Again, we have investigated the availability of commercial FSO system in Ghana using the atmospheric attenuation conditions and the optical link equation.

We used an 850nm wavelength FSO system (i.e. the MRV TereScope 5000). The system availability is estimated for propagation path lengths of 1km, 5km and 10km.

In Kumasi, the system availability has been estimated at 99.726%, 94.6747% and 76.0788% for propagation path lengths of 1km, 5km and 10km respectively. In Navrongo, the system availability has been estimated at 99.6233%, 96.7980% and 70.2398% for propagation path lengths of 1km, 5km and 10km respectively. In Accra, the system availability has been estimated at 100%, 94.8801% and 84.0411% for propagation path lengths of 1km, 5km and 10km respectively. In Bole, the system availability has been estimated at 99.7261%, 98.9042% and 80.0856% for propagation path lengths of 1km, 5km and 10km respectively. In Kete-Krachi, the system availability has been estimated at 99.9829%, 96.9863% and 88.2021% for propagation path lengths of 1km, 5km and 10km respectively. Finally, in Wa, the system availability has been estimated at 100%, 95.1199% and 82.5343% for propagation path lengths of 1km, 5km and 10km respectively. The system availability decreases with increase in propagation path. The system availability can be increased by increasing the transmitted optical power.

From this research, we can conclude that Free Space Optical Communication is feasible in Ghana.

5.1.1 Recommendation

Attenuation due to scattering by the atmosphere causes the most detrimental effect for Free Space Optical Communication as evident in this research. Strategies to mitigate the effects of the local visibility conditions on free space optical signals are needed to realize the full benefits of FSO Communication. Effective Pointing, Acquisition and Tracking techniques for FSO systems remain a major challenge and therefore must be actively researched.

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APPENDIX A

METEOROLOGICAL VISIBILTY MEASUREMENTS [KM]

ACCRA 2010

JANUARY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	10	6	3	8	15	15	15
2	15	15	6	5	10	12	12	15
3	15	12	7	4	8	8	10	10
4	10	10	3	3	8	10	10	10
5	10	10	5	3	5	10	10	10
6	10	10	10	3	4.5	8	10	10
7	10	10	4	5	8	8	8	10
8	12	12	8	4	5	8	10	10
9	10	10	3	3	5	8	10	10
10	10	10	3	4	5	10	10	10
11	10	10	10	3	7	12	12	12
12	12	12	3	6	8	12	15	15
13	15	12	3	4	5	8	10	10
14	10	10	3.5	4	8	10	10	10
15	10	10	10	4	4	10	4	10
16	10	10	10	5	5	10	10	10
17	10	10	10	8	12	12	12	15
18	15	15	3	3	10	10	10	10
19	10	10	3	4	6	8	10	10
20	10	10	3	3	5	6	6	10
21	10	10	3	2.5	3	5	5	10
22	10	10	3	2.5	5	5	6	10
23	10	10	2.5	3	4	5	5	10
24	10	10	3	3	6	8	10	10
25	10	10	3	3	4	8	10	10
26	10	10	10	3	5	8	10	10
27	10	10	10	5	8	8	10	12
28	12	12	10	10	10	10	10	10
29	10	10	4	6	10	10	10	10
30	10	10	10	5	8	10	10	10
31	10	10	10	5	8	12	12	12

FEBRUARY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	10	6	10	10	10	10
2	10	10	10	5	5	7	10	10
3	10	10	8	5	8	10	10	10
4	10	10	10	3	8	10	10	10
5	10	10	10	4	7	15	15	10
6	12	12	8	4.8	8	12	12	10
7	10	10	3	3	4	4	5	10
8	10	10	6	4	4	5	8	10
9	10	10	5	4	4	5	10	10
10	10	10	5	4	8	8	10	10
11	10	10	10	10	10	12	12	12
12	12	12	10	10	10	12	12	12
13	12	12	10	8	10	10	12	12
14	12	5	10	10	12	12	12	12
15	12	12	10	10	12	12	12	12
16	15	15	12	10	15	18	18	16
17	16	16	10	10	15	15	15	12
18	12	12	8	10	12	18	18	12
19	12	12	12	10	15	15	15	15
20	10	10	10	10	12	15	15	15
21	15	15	12	10	15	15	15	15
22	15	12	10	10	15	15	15	15
23	12	12	10	6	10	16	16	12
24	12	12	10	10	14	14	14	14
25	10	10	10	10	10	12	12	12
26	12	12	10	8	15	18	16	15
27	15	15	10	12	15	15	15	13
28	13	13	10	10	10	16	16	15
29								
30								
31								

MARCH								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	5	8	15	15	15	15
2	15	15	5	10	12	15	15	15
3	15	15	10	8	12	15	15	15
4	15	15	10	12	15	15	15	15
5	15	15	8	8	10	10	10	10
6	10	10	10	10	14	15	15	15
7	10	10	10	10	15	15	15	15
8	15	15	5	8	15	18	16	15
9	15	15	10	10	10	12	12	10
10	12	12	10	12	12	16	16	10
11	10	10	10	10	20	20	20	16
12	10	10	10	12	15	15	15	15
13	15	15	12	12	18	18	18	10
14	10	10	10	12	15	15	12	12
15	12	12	10	10	10	10	10	10
16	10	10	10	10	12	12	12	12
17	10	10	10	10	12	15	15	15
18	15	15	10	12	15	16	16	14
19	14	14	12	10	10	10	15	12
20	12	12	8	10	10	10	10	10
21	10	10	10	6	10	12	12	12
22	10	10	3	3	0.5	0.8	0.8	3
23	3	3	2.5	1.5	2	2	2	3
24	3	3	3	3	1.5	1.5	2	3
25	5	5	2	2	2	2	2	4
26	4	4	3	2	2	3	3	6
27	6	6	3	3	3	3	3	8
28	8	8	5	3.5	3.8	4	5	8
29	8	8	3	5	5	5	5	8
30	8	8	3.5	3	5	6	8	10
31	10	10	5	3	4	8	8	10

APRIL								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	10	4	4	5	7	7	10
2	10	10	10	10	12	16	16	16
3	16	16	10	12	12	15	15	12
4	12	12	10	10	20	20	20	15
5	15	15	10	10	15	20	20	16
6	10	10	10	15	15	17	17	16
7	16	16	10	12	15	15	15	15
8	15	10	10	12	12	15	15	12
9	12	12	10	10	18	18	18	15
10	15	15	3	10	15	15	15	15
11	10	10	12	10	12	15	15	15
12	15	15	15	16	18	18	18	18
13	15	15	10	15	15	15	15	12
14	12	12	8	10	15	15	15	15
15	12	12	12	12	15	20	20	16
16	10	10	10	10	15	15	15	15
17	15	15	15	16	10	12	12	12
18	15	15	10	10	18	20	20	16
19	16	16	16	10	18	20	20	20
20	15	15	12	15	15	15	15	15
21	15	15	15	15	15	15	15	8
22	10	10	10	10	15	15	15	12
23	12	12	10	12	20	20	8	10
24	10	10	15	15	20	20	20	16
25	10	10	10	12	15	15	15	15
26	15	15	15	18	18	19	19	19
27	19	19	10	15	15	15	10	10
28	12	12	14	14	14	15	10	10
29	12	12	14	14	14	14	14	14
30	14	14	14	15	15	15	15	15
31								

MAY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	10	10	15	15	15	15	15
2	15	15	15	15	15	15	10	10
3	10	10	10	15	15	15	15	12
4	12	12	12	14	14	16	20	15
5	15	15	12	15	15	20	20	20
6	10	10	10	12	12	15	15	15
7	15	15	15	15	15	15	15	15
8	15	15	15	15	15	15	15	12
9	12	12	12	15	15	18	18	18
10	15	15	10	15	15	15	15	15
11	10	10	10	12	15	17	17	17
12	17	17	17	17	17	17	17	17
13	17	15	15	15	15	15	15	12
14	12	12	12	15	15	20	20	20
15	15	15	15	15	18	20	20	20
16	10	10	10	10	12	16	18	20
17	20	20	16	16	3	12	12	12
18	12	12	10	15	15	15	15	15
19	15	15	15	15	15	15	15	15
20	15	8	10	4	15	15	15	15
21	15	15	10	12	10	20	20	16
22	16	16	16	18	18	20	20	17
23	17	16	8	10	15	15	15	15
24	15	15	10	8	10	15	15	15
25	15	15	12	12	16	16	16	16
26	15	15	12	10	8	12	12	12
27	12	12	12	10	12	16	16	16
28	10	15	10	15	15	15	15	15
29	10	10	8	10	10	10	10	10
30	10	10	15	15	15	15	15	10
31	10	10	10	15	15	15	15	15

JUNE								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	10	10	10	12	12	12	12
2	12	12	7	15	15	15	15	12
3	12	12	12	12	18	18	18	15
4	15	15	10	5	10	8	12	12
5	12	12	10	10	12	15	15	15
6	15	15	15	12	16	16	16	16
7	12	12	10	10	12	16	16	16
8	10	10	8	10	15	15	15	15
9	15	10	10	15	15	15	8	10
10	10	10	8	10	10	10	10	12
11	12	12	12	12	16	16	16	16
12	16	16	2.5	10	15	15	15	15
13	15	15	15	15	15	15	15	15
14	10	12	12	12	13	13	13	13
15	10	10	10	12	12	12	12	12
16	12	12	8	8	0.8	8	10	12
17	12	12	10	12	15	15	18	18
18	15	15	3	10	10	15	15	15
19	15	15	3	10	15	15	15	15
20	12	10	8	10	3	8	15	15
21	15	15	3	10	8	10	10	12
22	12	12	3	12	15	15	15	15
23	15	15	2.5	10	12	15	15	15
24	10	12	12	12	10	12	12	12
25	12	12	3	3	12	15	15	8
26	12	12	12	12	12	12	12	12
27	12	12	8	15	15	15	15	15
28	15	15	10	10	13	15	15	15
29	15	15	12	12	12	15	15	15
30	15	15	10	10	12	15	15	15
31								

JULY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	15	15	15	18	8	10
2	10	10	1	10	14	15	15	15
3	15	15	8	10	10	15	15	15
4	15	15	5	10	15	15	15	15
5	15	15	10	10	15	15	15	15
6	15	15	15	15	15	15	15	15
7	15	15	12	10	15	15	15	12
8	12	12	4	10	15	15	15	15
9	15	15	3	10	15	15	15	15
10	15	15	3	10	12	10	10	10
11	12	12	12	10	10	16	16	16
12	16	16	3	10	15	15	15	15
13	12	12	10	10	14	14	14	14
14	14	14	14	14	15	15	15	15
15	15	15	15	15	15	15	15	15
16	15	15	5	2	8	1.5	10	12
17	12	12	10	15	15	15	15	15
18	15	15	5	10	15	15	15	15
19	15	15	12	12	12	15	15	15
20	15	15	10	12	15	12	12	14
21	14	14	12	12	16	16	16	16
22	16	15	8	12	12	15	15	15
23	15	15	15	15	15	15	15	15
24	15	15	15	15	15	15	15	15
25	15	15	10	12	15	15	15	15
26	15	15	15	15	15	15	15	15
27	15	10	10	14	18	18	18	6
28	8	10	8	14	15	15	15	15
29	12	15	5	5	12	15	15	15
30	15	15	10	15	15	15	15	15
31	15	15	7	10	15	16	16	16

AUGUST								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	7	10	15	15	15	12
2	12	12	3	8	15	15	15	15
3	15	15	10	10	15	15	15	15
4	15	15	5	10	15	15	15	15
5	15	15	5	10	12	17	17	17
6	15	12	12	12	15	15	15	12
7	12	12	10	10	10	15	15	15
8	15	15	12	8	10	15	15	15
9	15	10	5	12	12	12	10	10
10	10	10	10	10	17	17	17	16
11	15	10	10	8	10	10	3	10
12	10	8	8	10	16	16	16	16
13	16	16	12	12	14	15	15	8
14	10	10	5	10	12	15	15	15
15	15	15	10	3	10	16	16	16
16	15	15	5	10	12	15	15	12
17	12	12	10	10	3	5	10	10
18	10	10	10	15	15	15	15	15
19	15	15	3	10	15	17	17	15
20	15	15	10	10	15	5	10	12
21	12	12	2	10	15	15	15	12
22	12	12	6	10	10	15	15	15
23	15	15	12	4	14	15	15	15
24	15	15	4	10	12	15	15	15
25	15	15	10	12	15	18	18	16
26	15	15	3	10	15	15	15	12
27	12	12	10	10	12	15	15	15
28	15	8	10	12	14	14	14	14
29	14	14	10	12	12	15	15	15
30	15	8	5	8	12	16	16	16
31	16	15	10	10	10	15	15	15

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	6	10	15	15	15	15
2	15	15	12	12	15	15	15	15
3	15	15	8	12	15	15	17	15
4	15	15	12	12	16	18	18	18
5	16	15	8	12	15	15	15	13
6	13	13	4	5	10	15	15	15
7	8	10	10	15	18	18	18	15
8	15	15	5	12	15	15	10	15
9	15	15	10	12	15	18	18	16
10	16	1	8	10	15	15	15	15
11	12	12	10	10	15	15	15	15
12	15	15	10	12	15	15	15	15
13	10	10	10	13	15	15	15	15
14	15	15	15	16	18	18	17	15
15	15	15	15	15	15	18	18	10
16	10	12	12	14	17	17	17	15
17	15	15	10	12	15	15	15	15
18	15	15	10	8	7	10	15	15
19	15	12	12	16	16	16	14	12
20	12	12	12	12	15	12	12	12
21	12	12	12	18	18	18	18	18
22	18	15	10	12	18	18	12	12
23	10	10	6	5	15	15	15	15
24	10	10	10	12	16	18	8	10
25	5	12	10	15	20	20	20	12
26	8	10	10	10	15	15	15	15
27	15	15	12	18	18	18	18	10
28	15	15	12	12	15	15	15	15
29	15	15	12	12	16	18	16	16
30	16	16	10	18	18	18	18	16
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	10	12	15	15	15	15
2	15	15	12	15	15	15	15	15
3	15	15	15	15	15	15	15	15
4	15	15	15	16	16	18	18	18
5	18	10	10	18	18	18	18	18
6	15	8	10	15	15	15	15	15
7	15	15	15	15	15	15	15	15
8	15	15	10	15	15	15	15	15
9	10	10	10	15	15	15	15	15
10	15	15	10	12	12	12	12	10
11	8	10	10	15	15	15	15	15
12	15	15	15	15	15	15	15	15
13	15	15	8	12	15	15	15	15
14	15	15	15	16	16	8	12	12
15	15	15	12	12	18	18	18	15
16	15	15	16	16	16	16	16	16
17	16	16	15	15	15	15	15	15
18	15	15	10	10	15	15	15	15
19	10	10	10	15	15	16	16	16
20	16	15	12	8	10	10	10	10
21	10	10	10	12	15	15	15	15
22	15	15	15	15	15	15	15	15
23	15	15	10	12	15	18	18	18
24	10	10	10	16	18	18	16	15
25	15	15	15	15	15	15	15	15
26	12	12	14	14	15	15	15	15
27	15	15	4	12	14	14	14	15
28	14	10	10	15	15	18	18	14
29	14	14	14	15	18	20	20	16
30	16	16	10	15	15	18	18	16
31	12	12	12	12	15	15	15	15

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	12	12	15	15	15	15	15
2	15	15	10	15	15	18	18	18
3	10	10	6	10	18	18	16	16
4	16	16	5	10	18	18	18	15
5	15	15	15	16	16	16	16	16
6	16	16	8	10	14	15	15	15
7	15	15	10	15	15	15	15	15
8	8	10	10	12	15	16	16	16
9	16	16	5	12	15	15	15	12
10	12	12	8	10	15	15	15	15
11	15	15	15	12	12	15	15	15
12	15	15	10	10	12	15	18	15
13	15	15	15	16	18	18	18	15
14	15	10	10	15	18	18	18	15
15	15	15	15	16	20	20	20	20
16	20	15	12	15	15	15	15	15
17	15	15	12	15	18	18	18	15
18	15	15	15	16	16	18	18	16
19	16	16	10	15	15	18	18	12
20	12	12	8	10	15	15	15	15
21	15	15	8	8	8	10	10	10
22	10	10	10	10	12	15	15	15
23	15	15	12	12	16	18	16	18
24	18	18	5	10	15	15	18	15
25	15	15	8	10	15	18	18	18
26	18	18	5	12	15	15	15	15
27	15	15	8	10	15	20	15	10
28	15	15	12	15	16	16	16	20
29	18	18	6	12	15	15	15	12
30	12	12	8	10	15	15	15	15
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	3	10	15	15	15	15
2	15	15	5	10	12	15	18	15
3	15	15	3	10	18	18	16	15
4	15	12	5	15	15	15	15	12
5	12	12	6	12	12	15	10	10
6	10	12	12	12	15	15	15	15
7	15	15	10	10	15	15	15	15
8	15	15	15	12	16	16	16	16
9	15	15	5	10	10	15	15	12
10	12	12	6	10	12	12	12	12
11	12	12	3	10	10	15	12	12
12	12	12	5	10	12	15	12	10
13	12	12	10	5	10	18	16	15
14	15	10	5	5	8	8	8	12
15	12	12	4.5	5	8	8	10	10
16	10	10	3	5	5	12	12	12
17	12	12	3	5	10	10	10	12
18	12	12	4	4.5	10	10	10	12
19	15	15	4	4.5	10	12	15	12
20	10	10	3.5	3.5	8	8	10	10
21	12	12	3	5	10	12	12	12
22	12	12	5	8	10	15	15	15
23	15	15	5	8	12	15	15	15
24	15	10	5	5	8	10	10	10
25	10	10	5	3	8	10	10	10
26	10	10	3	5	10	12	12	12
27	12	12	3	5	10	15	12	12
28	12	12	10	7	12	12	12	12
29	12	10	3	3	10	12	12	12
30	12	12	3	5	10	12	12	12
31	12	12	5	3	4	2	2	3

2011 ACCRA

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	5	5	2	2	3	4	3	5
2	5	5	3	3	3	4	4	7
3	7	7	3	2	2	2	3	8
4	8	8	5	2	2	3	5	5
5	8	8	3	3	3	3	4	5
6	8	8	3	3	3	3	4	5
7	10	10	5	2.5	3.5	4	6	8
8	8	8	2	2	4	3	3	6
9	6	6	2	2	2	2	2	3
10	3	3	1	0.8	1	1	1.5	3
11	2	2	2	1	1	1	1	1
12	2	2	2	0.6	0.6	0.7	1.2	1.5
13	2	2	0.8	0.8	0.8	0.8	0.6	1
14	1.5	1.8	0.8	0.8	0.8	0.8	0.8	1
15	0.8	0.8	0.8	0.7	0.7	1	1	1
16	1	2	2	2	3	3	3	8
17	8	8	8	2	2.5	1.5	1.5	4
18	5	5	1	0.7	0.8	0.8	1	2.5
19	3	3	2	1	1	1	1	3
20	3	3	3	1	1	1	1.5	2
21	2	2	2	2	2	2	2.5	6
22	6	6	6	2.2	2.8	3.2	3.5	8
23	8	8	5	3	5	5	5	8
24	8	8	5	3	5	6	6	8
25	8	8	8	5	8	8	8	10
26	10	10	3	5	6	8	8	10
27	10	10	4	5	6	10	10	12
28	12	12	8	4	6	10	10	10
29	10	10	5	5	8	10	10	12
30	12	12	12	4	10	10	10	10
31	10	10	10	3	8	10	15	15

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	10	6	10	15	13	12
2	15	15	10	6	10	12	12	13
3	12	12	8	8	8	8	10	10
4	10	10	10	2	3	5	6	10
5	10	10	10	5	5	5	5	10
6	10	10	10	3	5	10	10	12
7	12	12	8	6	8	10	10	10
8	10	10	8	8	10	15	15	15
9	15	15	10	5	10	12	12	12
10	12	12	10	8	8	8	10	12
11	12	12	8	4.5	8	8	8	10
12	10	10	8	8	15	15	15	12
13	12	12	8	10	15	15	15	15
14	15	15	12	12	12	15	15	15
15	15	15	10	5	5	8	12	12
16	12	12	12	5	10	15	16	16
17	16	16	10	10	15	15	15	15
18	12	12	8	5	15	15	10	10
19	10	10	10	12	12	12	12	12
20	12	12	10	5	12	12	15	15
21	15	15	15	10	15	18	18	15
22	15	15	10	10	12	15	15	12
23	6	8	10	8	16	16	16	16
24	16	16	3	10	14	14	14	14
25	14	14	8	5	13	15	15	15
26	8	10	10	12	15	16	16	15
27	15	15	10	15	15	15	18	12
28	12	12	10	10	16	16	18	18
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	12	12	15	15	15	15
2	15	15	10	8	12	15	15	15
3	15	15	10	12	15	18	17	13
4	12	12	10	10	10	10	10	10
5	10	10	10	10	14	18	18	18
6	18	15	10	10	15	15	15	15
7	15	15	8	10	12	15	15	15
8	15	15	15	10	12	12	12	15
9	15	15	10	12	15	15	15	12
10	12	12	5	10	15	15	15	15
11	15	15	10	10	12	15	15	15
12	15	15	10	10	15	15	15	15
13	15	15	15	15	15	15	15	15
14	12	12	8	12	15	15	15	12
15	12	12	10	10	16	16	16	16
16	16	16	12	8	15	15	15	15
17	15	15	8	10	12	15	15	15
18	15	15	7	12	12	15	15	15
19	15	15	10	15	15	15	15	15
20	15	15	15	15	15	15	15	15
21	15	15	10	12	15	15	15	15
22	15	15	8	10	15	15	15	15
23	15	15	8	10	15	15	16	16
24	15	15	5	10	15	15	15	15
25	15	15	10	12	15	18	16	15
26	12	12	12	12	18	18	18	15
27	15	15	12	12	12	12	12	12
28	12	10	10	15	18	18	18	18
29	18	18	8	15	15	15	15	15
30	15	12	8	12	15	15	15	15
31	15	15	12	12	15	15	15	15

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	10	12	15	15	15	15
2	15	15	7	10	15	15	15	15
3	15	15	10	15	15	15	15	12
4	12	12	10	8	10	15	15	15
5	12	12	12	15	18	18	18	15
6	15	15	5	10	12	12	12	12
7	12	12	12	10	15	18	18	15
8	15	15	8	12	15	15	12	12
9	12	12	5	10	12	15	15	15
10	15	15	10	9	12	12	12	12
11	12	12	10	10	15	18	18	15
12	10	10	10	10	18	18	18	18
13	18	18	8	10	15	15	15	12
14	12	12	5	5	10	15	15	15
15	15	15	12	15	15	18	18	15
16	15	15	12	12	15	15	15	15
17	15	15	10	12	15	18	16	16
18	12	12	10	15	15	15	15	12
19	12	12	6	10	12	15	15	15
20	12	12	12	15	18	18	18	15
21	15	15	10	10	15	15	15	15
22	10	10	10	15	16	16	16	16
23	15	15	10	15	15	15	4	10
24	10	10	10	12	15	15	15	15
25	15	15	12	12	15	15	15	15
26	15	15	15	15	20	20	20	20
27	10	10	10	12	18	18	18	18
28	18	18	10	15	15	15	15	12
29	8	8	10	12	12	15	18	18
30	12	8	8	10	15	15	8	10
31								

MAY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	10	10	10	20	20	20	10
2	10	10	10	18	18	18	16	16
3	16	16	10	12	15	15	15	12
4	12	12	8	10	12	15	15	15
5	12	12	12	12	18	18	18	15
6	15	15	5	10	15	15	15	15
7	15	15	6	15	18	18	16	15
8	15	15	8	10	15	15	15	12
9	12	12	12	12	15	18	18	18
10	12	12	12	12	12	15	15	15
11	15	15	10	12	15	15	15	15
12	15	15	8	12	18	18	18	16
13	15	12	10	10	13	18	18	14
14	14	12	10	12	10	15	15	15
15	15	15	12	12	15	15	15	15
16	15	15	10	10	12	15	15	15
17	10	10	10	10	15	18	18	18
18	18	15	10	12	15	15	15	12
19	12	8	5	10	12	15	15	15
20	15	15	12	15	18	18	18	15
21	10	10	10	12	15	15	15	15
22	15	12	12	15	18	18	18	15
23	16	15	12	15	15	15	15	1
24	12	10	10	15	15	15	15	15
25	15	15	15	15	15	10	2	10
26	10	10	10	12	12	10	12	14
27	14	10	10	12	15	18	18	15
28	15	15	10	15	12	15	15	12
29	8	12	10	12	15	15	17	12
30	12	12	10	14	14	3	12	12
31	12	12	12	12	15	15	15	15

JUNE								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	10	15	16	16	16	12
2	15	15	10	15	15	15	15	12
3	12	12	10	8	15	15	15	15
4	12	12	12	15	15	15	8	8
5	12	12	12	12	18	18	18	18
6	10	10	10	12	18	18	18	15
7	15	15	12	15	15	15	15	15
8	12	12	12	15	15	15	15	15
9	12	12	12	15	15	15	15	15
10	15	15	15	15	15	15	15	15
11	10	10	10	10	15	15	15	15
12	10	10	15	15	15	8	12	12
13	12	12	12	12	15	15	15	15
14	12	12	6	10	18	18	18	18
15	15	12	10	10	12	18	18	18
16	15	12	8	12	15	18	18	18
17	18	12	5	10	15	15	15	15
18	12	12	8	10	15	15	15	15
19	15	15	15	15	15	15	15	15
20	12	12	5	10	15	18	18	18
21	10	10	8	12	16	16	16	16
22	12	12	2.5	5	10	12	12	10
23	10	8	6	8	10	15	15	15
24	12	12	10	10	10	13	13	13
25	13	12	5	5	12	15	15	15
26	15	15	8	10	15	18	16	15
27	12	12	3	15	15	15	15	12
28	12	12	6	12	15	15	12	12
29	10	8	5	10	10	12	12	12
30	12	12	5	5	10	10	12	12
31								

JULY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	10	8	3	12	16	16	16
2	15	15	3	5	12	12	12	12
3	12	10	6	8	0.8	8	10	10
4	10	10	5	10	15	18	18	15
5	12	10	5	10	15	15	15	15
6	15	15	5	10	15	15	15	15
7	10	10	10	10	12	15	15	12
8	12	12	3	5	10	12	12	12
9	8	12	12	12	12	12	12	12
10	12	12	6	10	12	6	6	10
11	10	10	6	12	12	12	12	12
12	12	12	8	10	15	15	15	15
13	15	12	5	10	12	15	15	15
14	12	12	5	12	12	14	14	14
15	14	14	5	10	12	12	12	9
16	10	10	3	8	15	15	15	15
17	12	12	5	15	15	15	15	12
18	12	12	3	10	10	15	15	12
19	12	12	12	15	18	18	18	15
20	15	15	5	10	12	12	15	15
21	15	10	10	2	12	16	16	16
22	16	16	5	3	15	15	15	12
23	12	12	3	10	15	15	15	15
24	12	12	12	12	12	16	16	16
25	16	16	10	10	15	15	15	15
26	10	10	10	5	10	14	14	12
27	12	12	8	12	15	15	15	15
28	15	15	8	10	12	15	15	15
29	15	15	12	15	15	15	15	15
30	15	15	12	12	15	15	15	15
31	15	15	10	15	15	15	15	15

AUGUST								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	15	15	15	15	15
2	15	15	10	10	12	12	12	12
3	12	12	7	10	10	10	10	10
4	10	10	3	10	12	12	12	12
5	10	4	3	8	5	12	12	10
6	10	10	10	12	15	15	10	10
7	10	10	6	6	15	15	15	15
8	15	15	12	12	14	18	18	15
9	15	15	10	7	10	10	10	10
10	12	10	10	10	15	15	15	15
11	15	15	5	10	15	15	15	15
12	12	12	6	10	15	15	15	15
13	15	10	5	10	10	10	10	10
14	10	10	10	10	12	12	12	12
15	10	10	10	12	10	14	14	14
16	14	10	10	15	15	15	12	10
17	10	10	8	10	12	13	15	15
18	15	15	12	12	15	15	15	15
19	15	15	10	10	15	15	15	15
20	15	15	10	14	15	14	14	14
21	14	14	14	15	15	15	15	15
22	15	15	10	10	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	10	15	15	15	15	15
25	10	10	10	10	12	16	16	16
26	16	16	5	5	10	12	12	12
27	12	12	10	10	12	12	12	12
28	10	10	10	8	12	12	12	12
29	12	12	10	10	15	15	15	15
30	12	12	10	12	15	15	15	15
31	15	15	10	12	15	15	10	10

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	10	10	10	12	15	15	15
2	15	15	12	15	15	20	20	20
3	15	15	10	10	12	15	15	15
4	10	10	10	12	12	12	12	12
5	12	12	15	18	18	18	16	16
6	16	16	10	10	15	18	18	18
7	15	15	15	12	15	15	15	15
8	15	15	15	12	12	15	15	15
9	15	8	10	8	12	14	14	14
10	15	15	10	15	15	15	15	15
11	15	15	10	12	15	18	18	15
12	15	15	12	12	10	12	12	12
13	12	10	12	10	12	15	13	13
14	10	10	10	10	14	15	10	10
15	15	15	15	15	15	12	12	12
16	10	10	10	12	12	15	15	15
17	15	15	12	12	14	14	14	14
18	14	14	10	12	15	15	15	15
19	15	15	8	12	16	18	18	18
20	18	18	10	15	15	15	15	10
21	10	8	10	10	12	15	15	15
22	15	12	12	10	10	15	15	15
23	15	15	10	12	15	15	15	15
24	10	10	10	10	16	16	16	16
25	15	15	12	15	15	15	15	15
26	15	15	10	12	15	10	10	10
27	10	10	10	15	15	12	12	12
28	15	15	10	15	15	15	15	15
29	15	15	8	10	15	18	18	15
30	15	15	15	15	10	10	10	10
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	10	10	10	12	10	12	15
2	15	15	10	9	18	18	18	18
3	18	18	18	12	15	15	15	15
4	10	10	10	15	15	18	18	18
5	15	15	15	15	15	15	15	15
6	15	15	15	15	15	18	18	18
7	15	15	15	15	15	15	15	15
8	15	15	10	10	10	15	15	15
9	15	15	12	15	18	18	18	18
10	12	12	10	18	18	18	18	15
11	15	15	15	15	18	18	18	18
12	18	18	15	8	15	15	15	15
13	15	15	10	12	15	15	15	10
14	18	10	10	10	15	18	18	18
15	15	15	15	18	18	18	18	18
16	15	12	12	16	16	18	18	18
17	18	15	12	15	15	15	15	15
18	15	15	10	12	15	15	15	15
19	10	10	10	16	18	18	17	15
20	15	15	8	12	12	15	15	12
21	10	12	10	12	15	18	18	18
22	15	15	15	15	15	15	15	15
23	15	15	10	10	15	15	15	15
24	10	10	10	15	15	15	4	12
25	12	5	10	12	12	15	15	8
26	8	8	8	15	18	18	18	18
27	15	15	10	10	14	18	18	18
28	15	15	10	15	15	15	15	15
29	15	15	8	15	15	15	15	15
30	15	15	10	10	12	15	15	15
31	15	12	12	12	15	15	15	15

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	10	15	15	15	15	15
2	15	15	10	10	15	15	15	15
3	15	15	10	15	18	18	18	18
4	15	15	12	12	15	15	15	15
5	15	15	15	15	18	18	18	15
6	15	15	15	15	15	15	15	15
7	15	15	10	12	15	15	15	15
8	10	10	10	15	18	18	18	18
9	15	12	10	10	15	15	15	15
10	15	15	15	15	18	18	18	18
11	18	15	10	14	14	14	14	14
12	14	14	10	10	10	18	18	15
13	15	15	10	15	18	18	18	18
14	15	15	10	15	15	20	20	15
15	15	15	15	15	18	18	18	18
16	18	18	5	10	12	15	15	15
17	15	15	5	10	12	12	12	12
18	12	12	5	12	15	15	15	15
19	15	10	5	8	15	15	15	15
20	15	15	6	10	15	15	15	15
21	15	15	5	10	10	10	10	10
22	15	15	5	10	12	15	15	10
23	10	10	10	12	15	16	16	16
24	15	15	10	5	12	15	15	15
25	15	15	8	8	10	12	12	12
26	12	12	4	12	12	15	15	15
27	15	15	5	10	12	15	15	15
28	15	15	10	10	18	18	18	18
29	15	15	5	8	12	12	12	12
30	12	12	8	5	10	12	15	15
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	4	10	15	15	15	15
2	12	12	5	5	10	10	7	10
3	10	10	5	8	15	15	15	15
4	12	12	4	8	10	15	15	15
5	15	15	4	8	10	15	15	15
6	15	15	5	8	10	15	15	15
7	15	15	5	4	10	12	10	10
8	10	10	3	8	12	12	12	12
9	12	12	5	4.5	10	12	12	10
10	10	10	3.5	5	8	12	12	15
11	10	10	4	8	8	8	8	10
12	10	10	4	6	2	2	2.5	10
13	10	10	4	1.5	1	1.5	2	3
14	5	5	3	0.8	1.5	1.5	2	5
15	6	6	1.2	1.5	1.2	1.5	2	5
16	5	5	2	1.5	1.5	1.5	2	5
17	5	5	2	0.8	1.5	2.5	2.5	5
18	5	5	1.5	2.5	3	3.5	5	10
19	10	10	10	5	4	4	4	10
20	10	10	5	2.5	5	8	10	10
21	10	10	3	3	8	8	8	10
22	10	10	3	5	7	7	8	10
23	10	10	8	4.5	6	10	12	10
24	12	12	5	4	5	10	10	10
25	10	10	4	7	10	10	10	15
26	15	15	4	4	8	10	12	12
27	15	15	4	4	8	10	12	12
28	12	12	4	4	8	12	12	12
29	12	12	10	5	5	5	5	10
30	10	10	4	5	8	10	10	12
31	12	10	4	3	8	8	10	12

BOLE 2010

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	6	6	6	6	6	6	6	6
2	6	6	6	6	4	4	6	6
3	6	6	6	6	5	5	6	6
4	6	6	6	6	5	5	5	6
5	6	6	6	6	5	5	6	6
6	6	6	6	6	6	6	6	8
7	9	9	9	9	9	6	6	6
8	6	6	6	6	5	5	6	8
9	8	8	8	6	6	6	6	6
10	8	8	8	6	5	5	6	8
11	8	8	8	8	5	5	6	6
12	8	8	8	6	5	6	6	6
13	8	8	8	6	6	6	6	8
14	8	8	8	8	6	6	6	6
15	8	8	8	8	6	6	6	8
16	8	8	8	8	6	6	6	6
17	8	8	8	8	6	6	6	8
18	8	8	8	6	6	6	6	6
19	8	8	8	6	6	6	6	8
20	8	8	8	6	6	6	6	6
21	8	8	8	6	6	6	6	6
22	8	8	8	8	6	6	6	6
23	8	8	8	8	6	6	6	8
24	8	8	8	8	6	6	6	8
25	8	8	8	8	6	6	6	8
26	8	8	8	8	8	6	6	6
27	8	8	8	8	6	5	6	8
28	8	8	8	8	8	8	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	6	6	6	6	8
31	8	8	8	8	6	6	6	8

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	8	8	8	8	8
2	8	8	8	8	8	8	8	8
3	8	8	8	8	8	8	8	8
4	8	8	8	8	8	8	8	8
5	8	8	8	8	6	6	6	6
6	8	8	8	6	6	6	6	8
7	8	8	8	8	6	6	6	8
8	8	8	8	8	6	6	6	6
9	8	8	8	8	8	6	6	8
10	8	8	8	8	8	8	8	8
11	8	8	8	8	8	8	8	8
12	8	8	8	8	8	16	16	16
13	10	10	10	16	16	16	16	16
14	14	14	14	14	8	8	8	8
15	12	12	12	12	10	9	16	16
16	15	15	15	16	16	16	12	16
17	16	16	16	16	16	18	18	16
18	16	16	16	16	18	18	18	16
19	16	16	16	16	18	16	16	16
20	16	16	16	16	18	18	18	16
21	16	16	16	16	18	18	18	16
22	16	16	16	16	18	18	18	16
23	16	16	16	16	18	18	18	16
24	16	16	16	16	18	18	18	16
25	16	16	16	16	18	18	18	18
26	16	16	16	16	16	9	12	12
27	15	15	15	16	18	18	18	16
28	16	16	16	18	20	20	20	20
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	16	16	16	18	18	16	16
2	16	16	16	18	18	20	20	18
3	16	16	16	18	18	18	18	16
4	16	16	18	18	16	16	16	16
5	16	16	18	18	18	18	16	16
6	16	16	18	18	18	16	16	16
7	16	16	18	18	18	18	18	16
8	16	16	16	16	18	18	16	16
9	16	16	16	17	18	18	16	16
10	16	16	16	18	18	18	18	16
11	16	16	16	18	18	18	16	16
12	16	16	16	16	18	18	16	16
13	16	16	16	18	18	18	18	16
14	16	16	16	16	18	18	18	16
15	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
17	16	16	15	15	15	18	18	10
18	14	15	15	16	18	18	18	18
19	16	16	16	16	16	17	17	16
20	16	16	16	16	17	17	17	16
21	8	8	16	16	5	4	5	6
22	6	6	6	0.1	0.1	0.1	0.1	0.2
23	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.4
24	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
25	0.4	0.4	0.4	0.8	0.8	0.8	0.8	0.8
26	0.8	0.8	0.8	0.8	0.8	2	2	2
27	2	2	3	3	3	3	3	3
28	3	3	3	5	5	5	5	5
29	5	5	5	8	8	8	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	8	8	8	8	8

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	6	6	8	8	8
2	8	8	8	8	9	9	9	9
3	9	9	9	9	9	9	9	12
4	12	12	14	16	16	16	14	14
5	14	14	14	16	16	18	18	18
6	16	16	16	16	16	16	16	16
7	15	15	15	15	16	16	16	16
8	16	16	16	16	16	16	16	16
9	15	15	16	16	16	16	16	16
10	16	16	16	16	16	16	16	16
11	16	16	16	16	16	16	14	14
12	14	14	14	16	16	16	16	16
13	16	16	16	16	16	16	16	16
14	16	16	16	16	17	17	16	16
15	16	16	16	16	16	16	16	16
16	8	14	16	16	16	16	16	16
17	16	16	16	15	16	16	16	16
18	16	16	16	16	16	16	16	16
19	16	16	16	16	16	18	3	16
20	16	16	16	16	16	16	16	16
21	16	16	16	16	16	18	18	16
22	16	16	16	18	18	18	18	16
23	16	10	16	16	18	18	18	16
24	16	16	16	18	18	18	10	16
25	16	16	16	16	18	18	18	16
26	16	16	16	18	18	18	18	16
27	16	16	16	18	18	18	18	16
28	16	16	16	16	16	16	16	16
29	16	16	16	16	16	16	16	16
30	14	16	16	16	16	16	16	16
31								

MAY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	18	18	15	11	6
2	14	14	16	18	18	18	16	13
3	13	13	16	16	16	16	16	16
4	16	16	16	16	16	16	16	14
5	14	14	14	16	18	18	10	10
6	10	10	13	16	18	18	18	16
7	16	16	16	16	16	16	16	16
8	16	16	16	16	18	18	18	14
9	14	14	14	16	18	18	18	18
10	16	16	16	16	16	16	16	13
11	16	16	16	16	16	18	18	16
12	14	14	14	16	18	18	18	16
13	16	16	16	18	18	18	18	15
14	15	15	15	16	16	16	16	16
15	14	14	14	17	17	18	16	16
16	14	14	16	18	18	18	18	14
17	14	14	14	17	17	18	18	18
18	14	14	14	16	16	16	16	16
19	16	16	14	14	14	18	8	14
20	14	10	10	16	16	16	16	16
21	6	7	14	16	18	18	18	18
22	12	12	12	14	16	18	18	16
23	16	14	14	18	18	18	18	16
24	16	16	16	18	18	18	18	15
25	15	14	14	17	17	16	16	16
26	14	14	14	14	16	18	18	16
27	16	14	14	16	18	18	18	16
28	16	16	16	16	18	18	18	14
29	14	14	14	17	17	16	16	16
30	14	14	16	16	18	18	16	16
31	16	16	16	18	18	18	18	16

JUNE								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	14	14	14	14	14
2	14	14	14	16	16	16	16	16
3	16	16	16	16	18	18	18	18
4	18	18	6	6	16	16	16	16
5	16	16	16	16	16	16	16	14
6	14	14	14	16	18	18	18	16
7	16	16	16	16	16	16	16	14
8	14	14	16	16	16	16	16	16
9	16	16	16	16	18	18	18	16
10	16	8	14	16	18	18	18	18
11	16	16	16	18	16	16	16	14
12	14	14	14	14	14	18	8	14
13	14	14	14	16	18	18	18	16
14	16	16	16	18	18	18	18	15
15	15	15	15	15	15	16	16	16
16	14	14	14	16	18	18	14	14
17	2	6	14	15	18	18	18	15
18	15	15	15	15	18	18	18	16
19	16	16	16	16	18	18	18	16
20	16	16	16	18	18	15	15	15
21	15	15	15	15	15	18	18	16
22	16	16	16	16	18	18	18	6
23	16	16	16	18	18	18	18	15
24	15	15	15	15	18	18	18	16
25	3	12	12	14	16	16	16	16
26	14	14	14	15	8	15	15	15
27	15	15	15	18	18	18	18	16
28	16	16	16	16	18	18	18	16
29	16	15	15	18	18	18	18	14
30	14	14	14	14	17	18	18	18
31								

JULY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	18	15	15	15
2	15	14	14	18	18	18	15	15
3	15	15	15	19	19	19	18	16
4	16	16	16	16	18	18	18	16
5	16	16	16	16	18	18	15	12
6	15	15	15	18	18	16	16	16
7	14	14	14	16	16	18	18	16
8	15	15	14	16	18	18	18	15
9	15	15	15	15	18	18	18	16
10	16	16	16	16	18	8	14	14
11	14	14	14	14	16	16	14	14
12	14	14	14	14	17	18	18	16
13	16	16	16	16	18	18	18	16
14	16	16	16	18	18	18	18	15
15	15	15	15	15	16	16	16	16
16	16	16	16	16	18	18	18	16
17	16	8	14	16	16	16	16	16
18	14	14	14	17	17	16	16	16
19	16	16	16	16	18	18	18	16
20	16	15	15	16	18	8	18	15
21	15	15	15	15	17	18	18	16
22	16	16	16	16	18	18	18	16
23	16	15	15	16	18	18	15	15
24	15	15	15	15	15	18	18	16
25	16	16	16	18	18	18	18	16
26	16	16	16	18	18	18	18	15
27	15	15	15	15	15	16	16	16
28	16	16	16	16	18	18	18	16
29	16	15	14	16	18	18	18	15
30	15	15	15	18	18	18	16	16
31	16	16	16	16	16	18	18	16

AUGUST								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	18	18	18	18	15
2	15	15	15	15	15	15	15	15
3	14	14	8	13	17	17	17	15
4	15	15	15	18	18	18	18	15
5	15	15	15	15	18	18	18	16
6	16	16	8	16	16	18	18	16
7	16	16	15	18	16	18	16	16
8	16	16	8	18	12	12	14	14
9	14	14	14	7	8	10	14	14
10	14	14	14	16	18	18	16	16
11	16	12	14	8	14	12	16	16
12	16	16	16	16	16	17	17	16
13	14	14	14	16	16	16	16	16
14	16	14	8	16	18	18	18	18
15	14	14	14	16	16	16	16	16
16	14	14	14	16	18	18	18	16
17	16	16	16	16	6	14	16	14
18	14	14	14	15	16	18	16	16
19	14	14	14	16	16	16	16	14
20	14	14	14	14	17	18	7	7
21	12	12	12	16	14	16	16	14
22	14	14	14	16	16	16	16	16
23	14	14	14	16	16	16	16	14
24	14	14	14	14	14	14	14	14
25	14	14	14	16	18	18	18	18
26	14	14	14	14	16	16	14	14
27	14	14	0.3	12	17	18	18	14
28	14	14	14	16	18	18	16	16
29	14	14	14	16	16	16	16	14
30	14	14	14	17	17	18	18	14
31	14	14	10	10	16	16	16	16

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	14	14	16	16	16	14
2	14	14	14	15	17	18	18	14
3	14	14	14	14	16	16	10	12
4	12	12	14	14	16	16	16	14
5	14	14	14	14	16	18	18	10
6	12	12	12	16	18	10	14	14
7	14	14	14	14	16	16	16	16
8	16	16	16	16	17	18	18	14
9	10	10	12	16	16	16	16	16
10	14	14	14	14	16	16	16	14
11	14	14	14	18	18	18	16	14
12	14	14	14	16	18	18	16	16
13	14	14	14	16	16	16	16	14
14	14	14	12	12	18	18	18	16
15	16	16	16	10	10	18	18	16
16	14	14	0.8	14	16	18	18	16
17	16	16	16	16	16	16	16	16
18	14	14	10	16	16	16	16	14
19	14	14	14	16	16	19	19	15
20	14	14	14	14	14	14	14	14
21	14	14	14	16	18	18	16	16
22	14	14	14	16	18	18	18	16
23	16	16	16	13	17	18	18	16
24	16	16	16	16	16	18	16	16
25	10	14	14	14	18	18	18	15
26	15	15	14	14	18	18	18	16
27	16	16	16	16	18	18	16	16
28	14	14	14	16	18	18	18	15
29	15	15	14	16	16	16	16	16
30	14	14	14	16	16	16	16	10
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	14	16	16	16	16	14
2	14	14	14	16	18	18	18	15
3	15	15	15	16	16	10	14	14
4	14	14	14	16	16	16	16	14
5	14	14	14	14	16	16	16	16
6	16	16	16	16	16	16	16	16
7	14	14	14	16	14	14	14	14
8	14	14	14	16	16	16	16	14
9	14	14	14	18	20	20	20	18
10	14	14	14	14	20	20	20	14
11	12	14	14	16	16	16	16	16
12	16	16	16	16	16	12	14	14
13	8	14	0.2	14	16	16	16	16
14	14	14	14	16	16	18	16	16
15	12	12	14	16	16	18	16	14
16	14	14	14	16	16	18	18	14
17	14	14	14	14	14	16	14	14
18	14	14	14	16	16	18	18	14
19	16	16	16	18	12	16	16	16
20	14	14	14	16	18	18	16	16
21	16	16	16	16	16	18	18	14
22	16	16	16	16	16	18	18	16
23	12	12	14	16	16	18	18	16
24	16	16	6	16	18	18	18	10
25	12	14	14	16	16	18	18	16
26	14	14	14	16	16	16	16	16
27	16	16	15	15	16	16	16	16
28	16	16	8	14	14	16	16	16
29	14	14	14	16	16	18	18	16
30	16	16	16	16	18	18	18	16
31	16	16	16	16	18	18	18	16

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	10	14	14	16	16	16
2	16	16	16	18	18	18	14	14
3	18	18	0.3	16	18	18	18	16
4	14	14	14	16	18	18	18	16
5	16	15	15	16	16	18	18	16
6	16	16	16	16	18	17	16	16
7	14	14	14	16	16	16	16	16
8	16	16	16	16	16	18	18	16
9	16	16	14	16	16	16	16	16
10	16	16	16	16	16	16	16	16
11	16	16	16	16	16	18	18	16
12	16	16	14	16	16	16	16	16
13	16	16	16	18	18	18	18	16
14	16	15	15	16	16	18	18	16
15	16	16	16	16	18	18	18	16
16	14	14	14	16	18	16	16	16
17	16	15	16	16	16	18	18	16
18	16	16	16	18	18	18	18	16
19	16	16	16	18	18	18	18	16
20	16	15	15	16	16	18	18	16
21	16	16	16	16	18	18	16	16
22	16	16	16	18	18	18	18	16
23	16	16	16	16	16	18	18	16
24	16	16	16	16	18	18	16	16
25	16	16	16	18	6	8	8	11
26	16	8	8	12	12	16	16	14
27	14	14	14	16	18	18	16	16
28	14	14	0.8	16	16	16	16	16
29	16	16	9	13	17	17	17	16
30	16	16	9	15	15	15	15	15
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	15	15	15	15	15	15
2	15	14	9	16	16	16	16	16
3	16	15	0.5	17	17	17	17	16
4	15	14	14	14	17	17	17	16
5	15	15	15	15	18	18	18	16
6	15	15	0.1	8	8	8	8	8
7	8	8	0.5	8	8	8	8	8
8	8	8	8	12	12	14	16	16
9	16	16	16	8	8	8	8	8
10	8	8	8	8	8	8	8	8
11	8	8	8	8	8	8	8	8
12	8	8	8	8	8	8	8	8
13	8	8	8	8	8	8	8	8
14	8	8	8	8	9	9	8	8
15	8	8	8	8	8	8	8	8
16	8	8	8	8	8	8	8	8
17	8	8	8	8	8	8	8	8
18	8	8	8	8	8	8	8	8
19	8	8	8	8	8	8	8	8
20	8	8	8	9	9	9	9	9
21	9	9	9	9	8	8	8	8
22	8	8	8	6	6	8	8	8
23	8	8	8	9	9	9	9	9
24	9	9	9	8	8	8	8	8
25	8	8	8	8	8	8	8	8
26	8	8	8	9	9	9	9	9
27	9	9	9	9	9	8	8	8
28	8	8	8	8	8	8	8	8
29	8	8	8	8	8	7	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	8	8	8	8	8

BOLE 2011

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	9	9	9	9	9
2	9	9	9	9	6	6	6	6
3	8	8	8	9	9	9	9	9
4	8	8	8	8	8	6	6	8
5	9	9	9	9	6	8	8	8
6	8	9	9	9	9	9	9	9
7	9	9	9	9	9	9	9	9
8	9	9	9	9	9	9	9	9
9	9	9	9	6	6	6	6	6
10	9	9	9	9	6	6	6	6
11	6	6	6	6	6	4	3	3
12	5	5	5	5	4	4	4	4
13	5	6	6	5	5	5	5	5
14	4	4	4	5	5	4	5	6
15	6	6	6	6	4	6	6	6
16	6	6	6	6	6	6	6	6
17	6	6	6	6	6	5	5	6
18	6	6	6	4	4	4	4	4
19	5	6	6	6	5	5	6	6
20	6	6	6	6	6	5	6	6
21	6	6	6	5	9	9	9	9
22	9	9	9	9	9	9	9	8
23	8	8	8	5	5	6	6	6
24	6	6	8	8	8	8	8	8
25	8	8	8	10	12	12	12	12
26	12	12	12	8	8	8	8	8
27	8	8	8	8	8	8	8	8
28	8	8	8	8	8	8	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	12	15	15	15	15

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	15	15	15	15	15	15
2	13	13	15	18	18	18	18	12
3	10	14	10	18	18	18	18	15
4	15	15	15	15	18	8	8	8
5	8	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	8
7	8	8	8	8	8	8	8	8
8	8	8	8	8	8	8	8	8
9	6	6	6	8	8	8	8	8
10	8	8	8	8	8	8	8	8
11	8	8	8	8	8	8	8	8
12	8	8	8	8	8	8	8	8
13	8	8	8	12	12	12	12	12
14	12	12	12	12	12	12	12	12
15	12	12	12	9	8	8	8	8
16	8	9	9	9	9	9	9	9
17	9	9	9	9	8	8	8	8
18	9	9	9	9	9	9	9	9
19	9	9	9	9	9	8	8	8
20	9	9	9	9	8	8	8	8
21	9	9	9	9	9	9	9	9
22	9	9	9	9	9	9	9	9
23	9	9	9	9	9	9	9	9
24	9	9	9	8	8	9	9	9
25	9	9	9	9	9	9	9	12
26	12	12	12	14	14	16	16	16
27	16	16	16	16	18	18	18	15
28	16	16	15	20	20	20	20	16
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	20	20	18	18
2	16	16	16	18	18	20	20	16
3	16	16	16	16	16	16	16	16
4	16	16	16	18	18	18	18	15
5	15	15	15	15	18	18	18	18
6	18	18	18	18	20	20	18	18
7	12	10	10	16	18	18	18	15
8	15	15	15	15	18	18	18	16
9	16	16	16	18	18	18	18	16
10	16	16	16	16	20	20	20	15
11	15	15	15	15	18	18	18	16
12	16	16	16	18	20	20	20	18
13	16	16	16	18	18	18	18	15
14	15	15	15	15	18	18	18	18
15	16	16	16	18	20	20	20	18
16	16	16	16	16	20	20	20	18
17	16	16	16	16	20	20	20	18
18	15	15	15	16	20	20	16	16
19	16	16	16	16	20	20	20	15
20	15	15	15	18	18	18	18	18
21	16	16	16	16	20	20	15	15
22	15	15	15	16	18	20	20	18
23	16	16	16	18	20	20	20	15
24	15	15	15	15	20	20	20	18
25	16	16	16	18	20	20	20	18
26	16	16	16	18	20	20	20	15
27	15	15	15	15	20	20	20	16
28	16	16	16	18	18	20	20	16
29	16	16	16	16	20	20	20	18
30	16	16	16	16	20	20	20	18
31	16	16	16	16	16	16	16	16

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	16	18	18	18
2	18	18	18	18	20	20	20	15
3	15	15	15	15	20	20	20	20
4	15	15	15	18	18	18	16	9
5	12	12	18	18	20	20	20	15
6	15	15	15	20	20	18	18	18
7	18	18	18	18	16	16	16	16
8	16	16	16	18	20	20	20	16
9	16	16	16	16	18	18	18	18
10	16	16	16	18	20	20	20	18
11	16	16	18	18	20	20	20	18
12	16	15	15	18	20	20	20	20
13	16	16	16	20	20	20	20	18
14	16	16	16	20	20	20	20	18
15	15	15	15	18	20	20	20	18
16	16	16	16	20	20	20	20	18
17	18	18	18	20	20	20	18	16
18	16	15	15	18	18	20	20	20
19	16	16	16	18	18	20	20	18
20	12	18	18	18	20	20	20	18
21	16	16	16	18	20	20	20	18
22	16	16	16	18	18	20	20	18
23	18	18	18	20	20	20	20	10
24	7	14	15	18	18	18	18	18
25	16	16	16	20	20	20	20	18
26	16	16	16	18	18	18	18	16
27	16	16	16	18	20	20	20	18
28	16	16	16	20	20	20	20	18
29	18	18	18	20	20	20	20	18
30	16	16	16	18	20	20	20	20
31								

MAY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	20	20	20	20	18
2	18	18	18	20	20	20	20	18
3	14	15	16	18	20	20	20	18
4	16	16	16	20	20	20	20	18
5	18	18	18	20	20	20	20	15
6	15	15	15	15	20	20	20	15
7	16	16	16	18	20	20	20	18
8	16	16	16	20	20	8	12	14
9	16	16	16	18	20	20	20	15
10	15	15	15	15	15	20	20	16
11	16	16	16	18	20	20	20	18
12	10	14	16	18	18	18	18	15
13	15	15	16	16	20	20	20	18
14	16	16	16	18	20	20	16	16
15	16	16	16	18	20	20	20	15
16	15	15	15	15	15	20	20	16
17	16	16	16	18	20	20	20	18
18	16	16	10	14	16	16	16	16
19	16	15	15	15	20	20	20	18
20	18	18	18	18	20	20	20	18
21	16	16	16	18	20	20	20	15
22	15	15	15	15	16	20	20	16
23	16	16	16	18	20	20	20	18
24	16	16	16	18	20	20	20	15
25	15	15	15	15	20	20	20	18
26	16	16	16	18	20	20	20	18
27	12	15	15	18	18	18	18	15
28	15	15	15	15	15	18	18	16
29	16	16	16	18	20	20	20	18
30	16	16	16	18	20	20	20	15
31	14	14	14	14	17	18	14	14

JUNE								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	14	18	18	20	20	18
2	16	16	16	18	20	20	20	18
3	16	16	16	18	20	20	20	18
4	16	16	16	18	20	20	18	18
5	16	6	8	16	20	20	20	16
6	16	16	16	18	20	20	20	16
7	16	16	16	16	20	20	15	14
8	14	14	14	18	20	20	20	18
9	16	16	16	18	20	20	20	15
10	15	15	15	15	15	18	18	18
11	15	15	15	18	20	20	20	16
12	16	15	15	18	20	20	20	15
13	15	15	0.8	17	18	20	20	18
14	15	15	15	18	20	20	20	16
15	16	16	16	18	20	20	20	15
16	15	15	15	15	15	18	18	16
17	16	16	16	18	20	20	20	18
18	16	16	16	18	20	20	20	15
19	15	15	15	15	15	18	18	16
20	16	16	16	18	18	18	15	15
21	15	15	15	18	18	18	18	15
22	15	15	10	15	15	18	18	18
23	15	15	15	18	20	20	20	16
24	16	16	16	18	20	20	20	15
25	10	10	15	15	15	18	18	16
26	16	16	16	18	20	20	20	16
27	16	16	16	12	16	16	16	16
28	16	16	16	16	16	18	18	18
29	15	15	15	16	18	18	18	16
30	16	16	16	16	16	16	16	16
31								

JULY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	16	18	18	16
2	16	16	16	18	20	20	20	16
3	16	15	16	18	20	15	15	15
4	15	15	15	16	16	18	18	18
5	16	16	16	16	16	18	18	16
6	16	16	15	15	16	16	16	16
7	16	16	16	16	16	20	20	28
8	16	16	16	16	16	18	18	18
9	16	16	16	18	20	20	20	15
10	13	15	15	15	15	18	10	14
11	14	14	14	16	16	15	15	15
12	15	14	10	16	16	16	16	16
13	16	16	16	16	16	18	18	16
14	16	16	16	16	16	18	16	15
15	15	15	15	16	16	16	16	16
16	16	16	16	16	16	16	16	14
17	14	14	14	18	18	18	18	16
18	16	16	15	8	14	14	14	14
19	14	14	14	16	16	18	16	16
20	16	16	16	16	16	18	18	16
21	16	15	10	18	18	18	18	15
22	15	15	15	18	18	18	10	14
23	14	14	14	16	18	18	18	16
24	16	16	16	18	18	18	18	15
25	15	15	15	15	18	18	18	18
26	16	16	16	16	16	18	18	16
27	16	16	16	16	16	18	18	16
28	16	16	16	16	16	18	18	16
29	16	16	16	18	18	18	15	15
30	15	15	15	10	16	16	16	16
31	16	16	16	16	16	18	18	16

AUGUST								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	18	18	18	18	12
2	14	16	16	16	18	18	18	15
3	15	15	15	16	16	16	16	16
4	16	16	16	10	10	18	14	14
5	14	0.1	15	17	18	18	18	15
6	15	15	15	15	15	16	16	16
7	16	16	16	16	16	18	18	16
8	16	16	16	16	16	16	16	16
9	16	16	16	15	16	16	16	16
10	16	16	16	16	16	18	18	16
11	16	16	16	16	16	18	18	16
12	16	16	16	16	16	18	18	18
13	15	15	15	16	16	10	15	15
14	15	15	15	17	18	18	18	15
15	8	15	15	15	15	18	18	16
16	16	16	16	16	16	16	16	16
17	16	14	15	15	15	18	18	16
18	16	16	16	16	16	18	18	16
19	16	16	16	18	18	18	18	15
20	16	16	16	16	16	18	18	16
21	16	16	16	16	18	18	18	16
22	16	16	16	16	16	16	16	16
23	16	16	16	16	16	16	16	16
24	16	16	16	16	16	18	18	15
25	15	15	15	15	18	16	16	16
26	16	16	16	8	16	10	10	14
27	15	15	15	16	18	18	18	15
28	15	15	12	12	16	16	18	16
29	16	16	16	16	18	18	18	16
30	16	16	16	16	16	18	18	15
31	10	10	15	16	18	18	16	16

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	15	16	16	16	16	16
2	16	16	16	16	16	18	18	10
3	15	15	15	15	16	16	16	16
4	16	16	16	16	16	18	18	16
5	16	16	16	16	16	18	18	16
6	15	15	15	15	16	18	16	14
7	14	14	14	15	18	18	18	16
8	16	16	16	16	18	18	13	13
9	13	15	15	15	15	18	18	16
10	16	16	16	16	18	18	13	15
11	15	14	15	17	18	18	18	15
12	15	15	15	15	17	16	16	15
13	15	15	15	16	18	18	18	16
14	16	16	15	15	18	18	18	16
15	15	15	15	15	15	18	18	18
16	16	16	16	16	18	18	18	16
17	15	14	14	12	12	15	15	15
18	15	15	15	15	15	18	18	16
19	16	16	16	16	16	18	18	16
20	16	16	16	18	18	18	18	15
21	15	15	15	15	18	16	16	8
22	13	13	13	16	16	18	18	16
23	15	15	15	18	18	18	18	15
24	15	15	15	15	15	16	14	15
25	15	15	15	16	16	18	18	16
26	15	15	15	18	18	18	18	15
27	14	14	14	14	15	18	18	16
28	16	16	16	16	16	18	18	16
29	8	14	15	17	18	18	18	15
30	15	15	15	15	16	18	18	10
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	15	15	18	18	18	18	16
2	16	16	16	18	18	18	18	15
3	15	15	15	15	18	18	18	16
4	16	16	16	18	18	18	18	15
5	15	14	16	16	18	18	16	16
6	15	15	0.7	17	18	18	16	16
7	16	14	18	18	18	15	15	15
8	15	15	16	16	15	14	16	16
9	9	9	15	18	18	12	18	12
10	16	16	16	12	18	18	18	15
11	15	15	15	18	18	18	16	16
12	16	16	16	16	18	18	18	16
13	16	16	16	18	18	18	18	15
14	15	15	15	15	17	18	18	16
15	10	15	15	16	18	18	18	16
16	8	15	15	18	18	18	18	15
17	15	15	15	16	17	18	18	16
18	16	16	16	16	18	18	18	16
19	16	15	15	18	18	18	18	16
20	16	16	16	18	18	18	18	15
21	16	16	16	16	17	18	18	16
22	16	16	16	18	18	18	18	16
23	16	15	15	18	18	18	18	16
24	16	16	16	17	18	18	18	15
25	15	15	15	15	16	18	18	16
26	16	16	16	16	14	18	18	16
27	16	16	16	18	18	18	18	16
28	16	16	16	16	17	17	17	15
29	15	15	15	18	20	20	18	18
30	16	16	16	18	18	20	20	16
31	16	15	15	18	18	20	18	18

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	17	18	18	15
2	15	15	15	15	15	18	18	16
3	16	16	15	16	18	20	15	15
4	15	15	15	15	18	18	18	16
5	16	16	16	16	18	18	18	15
6	15	15	15	15	20	20	18	18
7	15	15	15	18	20	20	18	18
8	15	15	15	16	20	20	20	15
9	15	15	15	20	20	20	20	18
10	15	15	15	16	20	20	16	16
11	15	15	14	16	20	15	15	15
12	12	14	8	15	15	18	18	16
13	16	16	16	18	18	18	18	15
14	15	8	8	18	18	18	18	15
15	8	8	8	12	20	20	20	16
16	8	8	6	16	16	16	16	16
17	15	8	8	20	20	20	20	16
18	16	16	16	18	20	6	6	15
19	15	8	8	16	16	18	18	15
20	15	15	15	15	20	20	18	16
21	16	16	16	18	20	18	18	16
22	16	16	16	18	20	20	15	15
23	15	14	8	15	20	20	15	15
24	15	15	15	16	16	20	18	18
25	15	15	15	18	18	18	18	16
26	16	16	16	14	18	18	18	16
27	15	15	8	18	20	20	20	16
28	16	16	16	18	20	18	18	16
29	16	16	9	14	16	18	18	18
30	16	8	7	9	9	9	9	9
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	9	9	9	12	8	8	8	8
2	8	8	8	6	6	6	6	6
3	6	8	8	8	8	8	8	8
4	8	8	8	8	8	6	6	8
5	8	8	8	8	8	8	8	8
6	8	8	7	7	9	9	9	9
7	9	9	9	9	9	8	8	8
8	8	8	8	8	5	6	6	6
9	6	6	8	6	6	8	8	6
10	6	6	6	6	6	6	6	6
11	6	6	6	6	6	6	6	6
12	6	6	6	5	5	5	5	5
13	5	5	5	5	5	6	6	6
14	6	6	6	6	6	6	6	6
15	6	6	6	6	6	6	6	6
16	6	6	6	6	6	5	6	6
17	6	6	6	6	4	4	4	4
18	5	6	6	6	6	6	6	6
19	6	6	6	6	6	6	8	8
20	8	8	8	8	8	7	7	7
21	8	8	8	8	8	8	8	8
22	8	8	8	8	8	7	8	8
23	8	8	8	8	6	8	8	8
24	8	8	8	8	8	8	8	8
25	8	8	8	8	8	8	8	8
26	8	8	8	8	6	6	6	6
27	8	8	8	8	8	8	8	8
28	8	8	8	8	8	8	9	9
29	8	8	8	9	8	8	8	8
30	9	9	9	9	9	9	9	9
31	9	9	9	9	9	9	8	8

KETE-KRACHI 2010

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	20	24	24	24	20	16
2	16	16	8	9	9	8	7	7
3	7	7	6	8	8	8	8	7
4	7	7	6	8	8	8	8	7
5	7	7	7	8	8	8	8	7
6	7	7	7	9	9	9	9	9
7	9	9	9	9	9	9	9	7
8	7	7	8	9	9	9	9	8
9	8	8	0.1	8	9	9	8	7
10	7	7	7	8	8	8	8	7
11	7	7	7	9	20	20	20	15
12	9	9	7	9	9	9	9	8
13	6	6	6	8	9	9	9	8
14	8	8	8	9	9	9	9	8
15	8	8	8	9	9	9	9	8
16	8	8	8	9	9	9	9	8
17	8	8	8	9	9	9	9	7
18	7	7	6	9	9	9	9	9
19	8	8	8	8	8	8	8	7
20	7	7	7	8	8	8	8	6
21	5	5	5	6	4.8	4.8	4.8	4.6
22	4.6	4.6	4.6	5	5	5	5	4.6
23	4.6	4.6	4.6	4.8	4.8	4.8	4.8	4.5
24	5	5	5	6	6	6	6	6
25	6	6	6	8	8	8	8	7
26	7	7	7	8	8	8	8	6
27	6	6	6	22	24	26	22	18
28	18	18	19	24	26	26	23	18
29	18	18	18	26	26	26	26	18
30	18	9	9	9	9	9	9	7
31	7	7	6	5	8	8	8	6

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	6	6	6	7	7	6	6	6
2	6	6	6	7	7	8	8	6
3	6	6	6	6	6	6	6	5
4	5	5	5	9	9	9	9	8
5	8	8	8	9	16	16	16	9
6	6	6	5	8	8	8	8	6
7	6	6	6	8	8	8	8	6
8	6	6	6	6	6	8	8	6
9	6	6	6	8	8	8	8	6
10	6	6	6	9	9	9	9	8
11	9	16	18	24	6	7	26	15
12	15	15	15	22	24	7	16	16
13	16	16	16	24	26	26	26	16
14	16	16	18	26	26	26	23	18
15	18	18	18	25	30	30	25	16
16	16	16	18	24	26	26	22	15
17	15	15	18	26	26	26	20	16
18	7	14	18	28	28	28	22	16
19	16	15	18	26	26	26	22	18
20	18	18	20	25	25	25	22	16
21	16	16	20	26	26	26	20	18
22	15	15	15	26	26	26	20	16
23	16	16	20	26	28	26	24	18
24	16	16	20	26	26	26	24	18
25	18	18	20	28	28	28	28	18
26	18	18	20	26	26	26	26	20
27	15	15	18	26	26	26	22	18
28	18	18	20	26	28	28	22	16
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	20	25	28	28	28	18
2	18	18	22	25	28	28	28	20
3	18	18	18	26	26	26	26	20
4	20	20	20	26	26	26	26	18
5	18	18	20	26	26	26	20	16
6	16	16	20	26	28	28	24	16
7	16	16	18	25	25	25	25	16
8	16	18	22	26	26	26	26	20
9	18	18	18	26	26	26	20	18
10	18	18	20	24	26	28	24	16
11	16	16	20	26	26	26	24	18
12	18	18	22	28	28	28	28	20
13	20	20	25	26	26	26	26	20
14	20	20	20	26	26	26	26	18
15	16	16	20	28	28	30	22	16
16	16	16	18	24	26	26	24	18
17	18	18	22	25	30	30	28	16
18	16	16	22	26	26	26	26	20
19	15	15	20	25	28	28	28	20
20	18	18	20	24	24	24	18	15
21	15	15	15	18	8	3.8	1.5	1.5
22	1.5	1.5	1.2	1.2	0.8	0.8	0.8	1.2
23	1.2	1.2	0.9	1.2	0.9	0.9	0.9	1
24	1	1	1	1.2	1.2	1.2	1.2	1
25	1	1	1	1.2	1.2	1.2	1.2	1
26	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.5
27	1.5	1.5	1.5	2	2.5	4.5	4.5	4
28	4	4	4	4.5	6	6	6	6
29	6	6	7	8	8	8	8	7
30	7	7	8	8	8	8	8	7
31	7	7	8	8	8	9	8	7

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	7	7	8	8	8	8	8	7
2	7	7	8	12	12	12	12	12
3	14	14	18	20	22	22	20	16
4	16	16	20	22	22	22	22	18
5	16	16	20	26	28	28	24	17
6	17	17	19	24	26	26	22	18
7	18	18	20	24	26	26	26	16
8	16	16	22	26	26	26	20	18
9	18	18	18	26	26	26	22	16
10	16	16	20	26	26	26	23	18
11	18	18	22	28	30	30	30	16
12	16	16	23	24	26	28	24	18
13	18	18	20	26	26	26	26	16
14	16	16	20	25	26	26	24	0.9
15	18	18	24	26	26	26	22	18
16	18	18	24	28	28	30	30	18
17	18	18	20	22	24	24	22	20
18	18	18	18	25	30	30	30	18
19	18	18	22	26	26	26	24	20
20	18	18	20	26	26	26	24	18
21	18	18	22	25	30	30	30	18
22	18	18	24	25	25	30	25	20
23	20	20	20	28	30	30	30	19
24	19	18	22	26	26	16	20	15
25	15	15	18	26	26	26	24	19
26	19	19	22	25	30	30	30	18
27	18	15	22	24	24	26	22	18
28	18	18	20	28	28	30	30	18
29	18	18	24	26	26	26	22	16
30	16	16	22	26	26	26	24	18
31								

MAY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	20	20	20	26	28	30	25	18
2	18	18	22	28	30	30	26	20
3	20	20	24	30	30	30	22	20
4	12	18	22	26	28	26	24	20
5	20	20	22	24	26	28	22	18
6	18	20	24	28	28	28	24	20
7	20	20	24	28	28	28	25	18
8	20	20	24	28	28	28	20	16
9	20	20	24	26	28	30	25	18
10	18	18	22	30	30	30	26	20
11	20	20	22	16	24	24	22	18
12	18	18	25	28	28	28	24	18
13	18	18	22	24	26	28	20	18
14	18	18	22	28	28	26	24	18
15	18	18	22	26	28	26	24	18
16	18	18	20	26	26	26	24	18
17	18	18	23	28	28	30	25	18
18	18	18	24	28	30	30	25	20
19	20	20	25	13	26	26	24	18
20	18	18	23	28	28	28	24	18
21	18	18	24	28	26	28	22	18
22	18	18	22	28	28	28	24	20
23	20	20	24	28	28	28	24	18
24	18	18	25	28	28	28	24	18
25	18	18	24	24	24	28	25	18
26	18	18	22	28	30	30	25	20
27	20	20	25	30	30	30	26	15
28	20	20	25	30	30	30	20	15
29	18	18	22	22	24	28	25	18
30	18	18	22	28	30	30	15	15
31	15	15	20	28	30	30	25	20

JUNE								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	22	26	26	26	26	20
2	20	20	20	26	26	26	22	16
3	16	16	22	26	26	26	26	18
4	16	16	22	22	24	24	22	16
5	16	16	19	24	24	26	26	18
6	18	18	24	26	26	26	22	16
7	16	16	18	26	28	28	20	18
8	16	16	20	26	28	30	28	18
9	18	18	22	26	26	26	24	16
10	16	16	22	26	26	26	26	16
11	16	16	22	28	28	28	26	16
12	16	16	22	26	26	26	18	15
13	16	16	22	24	24	26	24	16
14	16	16	20	24	26	26	26	18
15	16	16	24	26	26	26	26	16
16	16	16	20	28	28	30	25	15
17	15	16	16	26	26	26	26	20
18	20	20	20	28	28	28	24	18
19	18	18	24	26	26	26	26	18
20	18	18	24	28	30	30	30	18
21	18	18	22	26	26	28	24	20
22	20	12	15	26	26	26	26	18
23	18	18	20	26	26	26	26	18
24	16	16	18	25	25	28	28	18
25	18	18	22	26	26	26	26	20
26	20	12	18	22	24	22	20	18
27	18	18	20	24	26	26	26	20
28	20	16	22	28	28	28	25	18
29	18	18	20	24	26	28	24	20
30	20	20	20	26	26	26	26	18
31								

JULY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	20	24	24	26	22	16
2	14	14	18	28	30	30	30	16
3	16	16	20	24	26	28	24	20
4	20	20	20	24	26	24	24	18
5	18	18	22	24	26	26	26	18
6	18	18	22	26	26	26	24	18
7	18	18	22	25	25	30	30	18
8	18	18	22	26	24	26	22	20
9	20	20	22	26	26	26	26	16
10	16	16	18	18	24	14	20	18
11	16	16	20	25	28	28	28	18
12	18	18	22	26	26	26	26	20
13	20	20	22	26	26	26	22	16
14	16	16	20	24	26	26	23	18
15	18	18	20	28	28	28	28	18
16	18	18	22	26	26	26	24	15
17	15	15	20	26	26	26	22	18
18	18	18	21	24	26	26	24	19
19	18	18	21	28	28	28	28	18
20	18	18	22	24	26	26	26	20
21	20	20	22	26	26	26	26	20
22	18	18	20	26	28	28	24	20
23	20	18	20	25	28	28	28	20
24	20	20	24	26	26	26	26	20
25	20	20	22	26	26	26	26	20
26	20	20	22	26	28	28	24	18
27	18	18	20	25	25	25	25	18
28	20	20	23	24	24	26	26	20
29	20	20	22	26	26	26	26	20
30	20	20	23	26	28	28	26	18
31	18	18	22	28	28	28	28	18

AUGUST								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	20	20	23	26	28	28	24	18
2	18	18	22	26	26	26	26	20
3	20	20	22	26	26	26	26	18
4	18	17	22	25	28	28	28	18
5	18	18	22	26	26	26	26	20
6	20	20	22	26	26	26	26	18
7	18	18	20	26	20	26	24	18
8	18	18	20	25	25	25	25	16
9	12	12	22	24	24	26	22	20
10	20	20	25	26	26	26	26	18
11	16	16	20	20	26	26	24	18
12	18	18	20	25	25	25	25	18
13	16	16	22	24	26	26	26	20
14	20	20	24	26	26	26	22	18
15	18	18	20	24	26	26	24	20
16	18	18	20	24	26	28	24	18
17	20	18	22	24	26	26	22	18
18	18	18	23	24	24	24	20	18
19	18	16	24	26	26	26	24	20
20	20	20	20	20	24	24	23	20
21	16	18	20	22	24	26	24	20
22	20	18	22	25	25	25	25	25
23	18	18	22	24	26	26	26	20
24	20	18	18	26	26	26	26	20
25	20	20	22	26	26	24	22	20
26	20	20	22	24	26	24	22	20
27	20	15	23	25	25	25	25	18
28	18	18	20	24	26	26	24	20
29	20	20	24	26	26	26	22	20
30	20	20	22	25	28	28	28	20
31	20	20	16	22	24	24	24	20

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	18	24	25	25	25	25	18
2	18	18	22	26	26	26	26	20
3	20	20	25	26	24	26	20	18
4	18	18	20	26	26	26	26	18
5	18	18	20	22	24	26	22	18
6	18	18	20	26	26	26	22	18
7	18	18	22	24	26	26	24	18
8	18	18	22	24	26	26	24	18
9	18	18	20	24	24	24	22	18
10	18	18	23	25	26	26	22	18
11	18	18	22	25	26	26	23	16
12	16	16	22	26	26	26	14	18
13	18	18	22	24	26	26	24	18
14	18	23	26	26	26	20	18	15
15	16	16	20	25	25	25	23	18
16	18	18	20	26	26	26	22	18
17	18	18	23	24	24	24	20	18
18	18	18	23	24	24	24	20	18
19	18	16	24	26	26	26	24	20
20	20	20	20	20	24	23	20	20
21	20	20	23	26	26	28	24	20
22	20	18	20	26	26	26	20	18
23	18	18	22	26	26	26	22	20
24	18	18	20	26	26	26	22	19
25	20	20	22	24	26	26	26	20
26	20	20	22	26	26	26	22	18
27	20	20	22	24	25	25	22	20
28	20	18	22	24	24	26	23	18
29	20	19	20	24	26	28	22	18
30	18	18	23	26	26	26	20	18
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	20	24	26	26	23	16
2	16	16	20	26	26	26	22	18
3	18	18	22	24	22	24	22	18
4	18	18	23	26	26	22	20	16
5	16	16	22	25	26	26	21	18
6	18	18	22	26	26	26	22	18
7	18	18	22	24	22	24	22	18
8	18	18	23	26	26	26	22	18
9	18	18	24	26	26	26	22	18
10	18	18	22	26	28	26	20	18
11	18	18	23	26	28	28	22	18
12	18	18	23	26	26	26	20	18
13	18	18	22	24	26	26	22	18
14	18	18	20	26	26	26	22	18
15	18	18	22	24	24	28	24	18
16	18	18	24	28	28	28	22	19
17	19	19	22	26	26	26	20	18
18	18	18	24	26	26	26	22	19
19	19	19	20	28	30	30	30	18
20	18	14	20	24	24	26	22	20
21	20	12	22	24	26	26	20	20
22	20	18	24	26	26	26	22	20
23	20	20	22	26	26	26	20	20
24	20	20	22	28	28	28	18	18
25	18	18	24	24	26	26	20	20
26	20	20	20	26	24	24	20	18
27	20	20	22	26	26	26	20	18
28	18	18	20	26	26	26	22	18
29	18	18	22	28	28	28	22	18
30	18	18	24	26	26	24	18	15
31	15	15	20	26	26	26	20	18

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	22	26	26	26	20	18
2	18	16	20	26	26	26	20	18
3	18	18	20	28	28	28	22	18
4	18	18	24	26	26	26	22	20
5	20	20	20	26	26	26	20	18
6	18	18	20	24	24	24	20	18
7	18	18	20	26	26	26	20	18
8	18	18	20	25	28	28	22	18
9	18	18	24	26	26	26	20	18
10	20	20	24	26	26	26	20	18
11	18	18	22	24	26	26	20	18
12	18	18	20	28	28	28	20	20
13	20	20	22	26	28	28	22	18
14	18	18	24	26	26	26	20	18
15	18	18	22	28	28	28	23	20
16	20	20	22	28	28	28	22	20
17	19	19	22	24	26	28	22	20
18	20	18	23	26	28	28	21	18
19	18	18	24	28	28	28	23	20
20	20	20	22	26	26	26	20	18
21	20	20	23	24	24	24	22	20
22	20	20	22	26	26	26	20	18
23	18	18	24	28	28	28	22	18
24	18	18	22	25	28	28	24	20
25	20	20	23	26	26	26	22	20
26	20	20	24	28	28	28	22	18
27	18	18	22	28	28	28	20	20
28	18	18	22	28	28	28	20	20
29	20	20	22	26	26	26	22	18
30	18	18	22	26	28	28	22	18
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	22	28	28	28	24	18
2	18	18	23	28	28	30	24	20
3	20	20	24	26	26	26	22	18
4	18	18	22	28	28	28	23	18
5	18	18	23	26	26	28	22	18
6	18	18	22	26	26	28	22	18
7	18	18	22	26	26	26	22	18
8	18	18	22	28	28	28	22	18
9	18	18	20	28	15	15	15	15
10	15	15	9	15	18	18	18	15
11	15	15	17	20	24	24	20	18
12	16	16	20	20	20	20	18	16
13	16	16	22	20	18	18	15	15
14	15	15	20	24	26	28	22	20
15	20	20	22	26	26	26	22	18
16	18	18	20	28	28	28	20	18
17	18	18	22	25	28	25	22	20
18	20	20	23	24	26	28	24	20
19	20	20	22	26	26	26	22	18
20	18	18	22	26	26	26	20	19
21	19	19	0.4	25	20	20	20	18
22	18	18	22	24	24	24	22	20
23	20	20	20	24	24	24	18	18
24	20	20	22	24	24	24	22	20
25	18	18	20	25	25	25	22	18
26	18	18	20	25	25	25	25	20
27	20	20	20	25	25	25	22	20
28	20	20	22	24	24	24	23	18
29	18	18	19	28	28	28	22	18
30	18	18	14	9	6	6	6	8
31	15	8	8	8	8	8	8	7

KETE-KRACHI 2011

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	7	7	7	6	6	6	6	7
2	8	8	8	8	8	8	9	8
3	6	6	6	7	5	5	5	5
4	5	8	6	6	6	6	6	5
5	5	5	7	8	8	8	7	6
6	6	6	6	9	9	9	9	6
7	6	6	6	8	8	8	8	6
8	6	6	8	8	5	5	5	6
9	6	6	6	5	2	2	2	3
10	3	3	3	3	3	3	3	2
11	2	2	2	2	1.5	1.5	1.5	1.5
12	1.5	1.5	1.5	1.6	1.6	1.2	1.2	1.2
13	1.2	1.2	2	2.5	2.5	2.5	2.5	2
14	2	2	2	2.5	2.5	2.5	2.5	2.5
15	2.5	2.5	3	3	3	3	3	2
16	2	2	2	3	3	3	3	2
17	2	2	2	3	2.5	2.5	2.5	2.5
18	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
19	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
20	2.5	2.5	2.5	2.5	1.6	1.6	1.6	1.6
21	1.6	1.6	1.6	2	2	2	2	1.6
22	1.6	1.6	1.6	1.8	4.5	4.5	8	8
23	8	8	8	8	8	8	8	8
24	8	8	8	15	15	15	15	13
25	13	13	13	20	24	26	22	18
26	18	18	20	24	24	24	22	18
27	18	18	20	24	24	24	22	18
28	18	18	19	24	26	28	24	18
29	18	18	22	26	26	26	26	18
30	18	18	20	26	26	26	26	18
31	18	18	20	26	26	26	26	18

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	20	24	26	26	24	18
2	18	18	20	26	26	28	24	18
3	18	18	20	26	26	26	24	18
4	18	18	18	25	25	25	25	18
5	8	8	8	9	9	9	9	8
6	8	8	8	9	9	9	9	8
7	8	8	8	9	9	9	9	9
8	9	9	9	9	9	9	9	9
9	8	8	8	9	9	9	9	9
10	9	9	9	15	15	15	15	13
11	13	13	20	26	26	26	20	18
12	18	18	18	26	26	26	23	18
13	18	18	20	26	26	26	20	18
14	15	18	20	28	28	28	25	20
15	20	20	22	26	26	26	22	18
16	18	18	20	26	26	26	22	20
17	20	20	24	26	26	28	24	20
18	20	20	20	28	28	28	20	18
19	18	18	20	26	26	26	22	20
20	20	20	22	26	26	26	26	20
21	20	20	22	26	28	28	26	18
22	18	20	22	28	28	28	25	18
23	18	18	20	26	26	26	20	18
24	18	18	18	26	26	26	26	20
25	18	18	20	28	28	28	25	18
26	18	18	20	26	26	28	26	20
27	20	20	25	28	28	28	22	15
28	18	18	20	26	26	26	26	20
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	20	20	24	26	26	26	25	18
2	18	18	22	24	26	26	24	18
3	18	18	21	26	28	28	20	18
4	18	18	20	24	26	28	24	18
5	18	18	20	26	26	26	26	18
6	18	18	22	26	26	26	26	18
7	18	18	20	26	28	28	26	18
8	18	18	20	26	28	28	25	16
9	16	16	20	26	28	28	24	18
10	18	18	22	26	26	26	26	18
11	18	18	22	24	28	28	24	18
12	18	18	20	28	28	28	24	18
13	18	18	22	26	26	26	26	18
14	18	18	22	26	26	26	26	18
15	18	18	20	24	28	28	24	18
16	18	18	20	26	28	28	28	18
17	18	22	22	24	28	28	24	18
18	18	18	22	26	26	26	26	20
19	20	20	22	26	28	28	24	19
20	19	19	22	26	28	28	24	19
21	19	19	22	26	26	26	24	18
22	18	18	22	26	26	26	22	18
23	18	18	20	26	28	28	22	18
24	18	18	20	24	28	28	24	18
25	18	18	22	26	26	26	26	18
26	18	20	23	26	26	26	24	18
27	18	18	20	24	24	24	24	18
28	18	18	22	26	28	28	25	18
29	18	18	22	26	26	26	22	18
30	18	18	22	26	26	26	24	18
31	18	18	20	26	28	28	24	18

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	22	26	28	28	24	18
2	18	18	24	26	26	26	24	18
3	18	18	22	26	26	26	22	18
4	18	18	20	24	24	24	22	18
5	18	18	22	26	26	26	22	18
6	18	18	22	26	28	28	23	18
7	18	18	18	26	26	26	22	18
8	18	18	22	24	26	26	24	18
9	18	18	22	26	28	28	22	18
10	18	18	20	25	28	28	25	18
11	18	18	22	24	28	28	24	20
12	20	20	24	26	26	26	26	18
13	18	18	22	28	28	28	25	20
14	20	18	20	28	30	30	25	20
15	20	20	24	26	26	26	24	20
16	20	20	24	26	26	26	24	20
17	20	20	22	28	28	28	22	16
18	20	20	22	28	28	28	25	18
19	18	18	22	26	26	26	22	20
20	20	20	20	26	26	26	22	18
21	18	18	22	28	24	28	24	18
22	18	18	22	28	30	30	25	18
23	18	18	22	26	26	26	22	20
24	20	20	22	26	26	26	24	18
25	18	18	22	26	26	28	22	18
26	18	18	22	26	26	26	26	18
27	18	18	24	26	26	26	22	18
28	18	18	22	26	26	26	24	18
29	18	18	22	26	28	28	24	18
30	18	18	22	26	26	26	22	18
31								

MAY								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	18	18	24	26	26	26	24	18
2	18	18	23	26	26	26	22	18
3	18	18	22	24	26	26	24	18
4	18	18	20	20	25	28	25	18
5	18	18	24	26	26	26	26	20
6	20	20	20	28	28	30	30	18
7	18	18	24	26	28	28	26	20
8	20	20	22	28	30	30	25	18
9	18	18	24	28	28	28	24	20
10	20	20	22	28	30	30	25	18
11	18	18	22	24	26	28	22	20
12	20	20	25	28	30	30	25	18
13	18	18	24	26	28	28	24	20
14	20	20	24	26	26	26	24	20
15	20	20	24	26	26	28	24	20
16	20	20	24	28	30	30	25	20
17	20	20	22	26	28	28	24	20
18	20	15	22	25	26	26	22	18
19	18	18	24	24	24	26	24	18
20	18	18	22	28	30	30	25	18
21	20	20	24	28	28	28	24	20
22	20	20	24	26	26	26	24	18
23	18	18	22	24	24	26	24	18
24	18	18	24	28	30	30	25	18
25	18	18	24	26	28	28	24	20
26	20	20	25	26	26	26	24	14
27	16	20	24	24	26	26	24	14
28	18	18	24	28	30	30	12	16
29	18	18	24	26	26	26	24	20
30	20	20	24	28	30	30	25	18
31	18	18	24	24	26	24	24	20

JUNE								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	20	20	24	30	30	30	25	18
2	18	18	24	28	28	28	26	20
3	20	20	24	26	26	26	22	15
4	16	16	24	24	26	26	24	15
5	16	16	24	26	26	26	24	18
6	18	18	24	26	26	26	24	20
7	18	18	22	26	26	22	22	20
8	18	18	24	24	24	24	22	15
9	18	18	22	26	26	26	24	18
10	18	18	22	26	26	26	24	20
11	20	18	24	26	26	26	26	20
12	20	20	24	26	26	24	24	20
13	20	18	22	26	26	26	24	18
14	20	18	24	28	28	28	26	20
15	20	20	24	24	26	26	24	20
16	18	16	22	24	24	26	24	20
17	20	20	22	28	30	30	25	18
18	18	18	22	24	26	26	24	20
19	20	20	22	26	26	26	24	18
20	20	20	24	26	26	26	22	18
21	20	20	22	28	28	28	25	18
22	18	18	22	24	24	24	24	20
23	20	20	24	26	26	26	24	18
24	18	18	23	24	24	24	22	18
25	18	15	22	28	30	30	25	18
26	18	18	20	25	28	28	24	20
27	12	14	15	24	26	26	24	18
28	18	18	24	24	26	26	24	18
29	18	18	22	28	28	28	25	18
30	18	18	22	20	24	26	24	15
31								

JULY								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	17	17	20	24	26	26	24	18
2	18	12	24	24	26	26	24	18
3	18	18	22	28	15	12	15	18
4	18	18	22	26	26	26	25	20
5	20	20	20	28	28	28	25	18
6	18	18	22	24	24	24	24	20
7	20	20	25	28	28	28	25	18
8	18	18	24	26	26	26	24	20
9	20	20	22	24	25	25	22	18
10	18	18	24	24	24	22	22	18
11	18	16	16	18	20	25	20	18
12	18	18	22	26	26	26	26	20
13	20	20	22	26	26	26	22	20
14	15	20	23	24	24	26	24	18
15	18	18	22	25	28	20	18	18
16	18	18	22	24	26	26	26	20
17	20	20	24	26	26	26	22	18
18	14	12	18	24	24	26	24	18
19	18	18	24	28	28	28	24	18
20	18	18	22	28	28	28	24	12
21	12	15	18	25	26	26	24	18
22	18	20	23	24	24	26	24	18
23	20	20	24	28	28	28	25	18
24	18	18	22	28	28	28	25	20
25	20	20	24	26	26	26	26	20
26	20	20	24	24	24	24	22	18
27	18	18	22	28	28	28	25	18
28	18	18	22	26	26	26	24	20
29	20	20	24	26	26	26	24	18
30	18	18	22	24	24	26	24	18
31	18	18	22	28	28	28	25	18

AUGUST								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	18	18	24	28	28	28	24	20
2	20	20	24	25	26	26	24	18
3	18	18	22	24	24	24	24	18
4	18	18	18	15	25	28	24	18
5	18	18	18	24	26	24	24	20
6	20	20	24	25	25	26	24	18
7	18	18	23	24	24	26	22	16
8	16	15	16	24	28	30	25	18
9	18	18	22	26	26	26	26	20
10	20	20	24	26	26	26	24	20
11	20	20	22	26	26	28	26	20
12	20	20	22	28	30	30	22	16
13	16	16	20	24	28	28	20	20
14	20	20	24	26	26	26	26	20
15	20	20	22	26	26	26	22	18
16	18	15	22	28	30	30	25	16
17	16	16	20	26	26	26	26	18
18	20	20	24	26	26	26	26	18
19	20	20	23	26	26	26	22	18
20	18	18	19	28	28	30	25	16
21	16	16	20	26	28	28	25	20
22	20	16	22	29	26	26	24	20
23	20	20	24	26	26	26	24	18
24	18	18	22	28	28	28	24	16
25	16	16	22	24	26	26	24	20
26	20	20	24	25	18	25	26	18
27	18	18	23	28	30	30	25	18
28	18	18	22	15	25	26	23	20
29	20	20	25	22	25	26	24	18
30	18	18	23	26	26	26	24	18
31	18	18	22	28	30	12	20	16

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	20	24	26	26	24	20
2	20	20	24	26	26	26	20	18
3	18	18	22	26	26	26	24	20
4	18	18	22	25	30	30	25	18
5	18	18	20	26	26	28	24	20
6	20	20	24	26	26	26	24	20
7	20	20	23	26	26	26	24	20
8	20	19	23	28	28	24	22	20
9	20	20	22	26	28	28	24	20
10	20	20	24	25	26	26	22	20
11	20	20	23	26	26	26	24	20
12	20	20	22	28	30	30	25	20
13	20	20	23	28	28	26	23	20
14	20	20	22	25	25	25	22	20
15	20	20	23	28	30	30	25	18
16	18	18	22	24	24	24	22	18
17	18	18	20	20	20	24	24	18
18	18	18	22	24	24	25	22	18
19	20	20	23	28	30	30	25	18
20	18	18	22	24	24	24	22	20
21	20	20	20	26	26	28	22	18
22	18	18	22	25	26	26	22	18
23	18	18	24	28	28	30	25	18
24	18	18	22	24	24	24	22	18
25	18	18	24	26	28	28	23	18
26	18	18	22	22	25	26	24	18
27	18	14	22	28	30	30	25	18
28	18	18	22	24	24	24	22	20
29	20	20	23	24	26	28	23	18
30	18	18	22	26	26	24	22	20
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	20	15	22	26	26	26	23	18
2	18	18	22	26	26	28	24	20
3	20	20	24	26	30	30	22	18
4	18	18	24	26	26	26	22	20
5	20	20	24	26	26	28	22	19
6	18	18	24	26	26	28	22	20
7	20	14	24	26	30	30	22	18
8	18	18	22	24	25	26	22	20
9	20	20	22	28	28	28	25	20
10	20	18	18	24	24	26	22	15
11	18	18	22	26	26	28	22	18
12	18	16	22	25	26	26	20	20
13	20	12	22	25	25	28	25	18
14	18	18	22	24	26	28	22	20
15	20	20	22	26	26	30	20	18
16	18	18	24	25	26	26	24	16
17	16	16	20	28	30	30	25	18
18	18	18	22	26	28	28	22	20
19	20	20	24	26	26	26	24	18
20	18	18	22	28	30	30	24	18
21	18	18	24	26	28	28	22	20
22	20	20	23	24	26	22	20	14
23	18	14	23	25	26	26	22	18
24	18	18	24	30	30	30	22	18
25	18	18	24	26	28	24	20	16
26	16	16	20	24	24	24	22	18
27	18	18	24	26	26	26	22	18
28	18	18	22	28	30	30	22	18
29	18	18	22	28	28	28	20	16
30	16	16	20	28	28	30	22	18
31	18	18	23	26	26	28	22	18

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	24	30	30	30	20	18
2	18	18	22	26	28	28	22	18
3	18	18	24	28	28	28	22	20
4	20	18	24	28	28	28	22	18
5	18	18	24	30	30	30	22	20
6	20	18	24	28	28	28	22	20
7	20	20	24	28	30	30	22	20
8	20	20	24	28	28	28	22	20
9	20	20	24	30	30	30	22	20
10	20	20	23	28	28	28	22	20
11	20	20	24	26	26	28	22	20
12	20	20	24	28	28	28	22	20
13	20	20	23	28	30	30	22	18
14	20	20	24	28	28	28	22	15
15	15	15	22	26	26	28	22	18
16	20	20	24	28	28	28	24	18
17	18	18	22	28	28	28	22	20
18	20	20	24	28	28	28	22	18
19	18	18	22	24	28	28	22	18
20	18	18	23	28	28	28	24	18
21	18	18	23	28	28	28	24	20
22	20	20	24	28	28	28	22	20
23	20	20	22	24	28	24	22	18
24	18	18	24	28	28	28	24	18
25	18	18	22	28	28	28	24	20
26	20	20	24	28	28	28	22	20
27	20	20	24	24	28	28	22	18
28	18	18	23	28	28	28	24	18
29	18	18	22	28	28	28	22	20
30	20	20	24	28	28	28	22	20
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	20	20	2	24	9	9	9	9
2	9	9	9	15	15	15	12	9
3	9	9	9	20	26	26	22	15
4	15	15	20	26	26	26	22	20
5	20	20	20	24	24	26	22	20
6	20	20	23	28	28	28	24	20
7	20	18	20	26	26	26	23	18
8	18	18	20	24	22	22	22	20
9	20	20	20	28	9	8	8	8
10	8	8	8	9	6	6	4.8	4.8
11	4.8	4.8	4.8	6	4.8	4.8	4.2	3.8
12	3.8	3.8	3.5	3	3	3	3	3
13	3	3	3	3.2	3.2	3.2	3.5	3
14	3	3	3	3.2	3.2	3.8	3.2	3
15	3	6	6	5	5	5	5	4
16	4	4	5	5	8	8	8	6
17	6	6	6	8	9	9	9	8
18	8	8	6	6	8	8	8	8
19	8	8	6	8	8	8	8	8
20	8	8	8	8	8	8	8	6
21	6	6	6	9	9	9	8	8
22	8	8	8	8	9	9	8	8
23	8	8	6	8	8	8	8	6
24	6	6	6	9	9	9	8	6
25	6	6	8	8	8	8	8	6
26	6	6	6	6	8	8	8	8
27	8	8	0.6	5	8	8	8	6
28	6	6	6	9	9	9	7	6
29	6	6	8	9	9	9	7	6
30	6	6	8	8	9	9	8	7
31	7	7	8	8	8	8	8	8

KUMASI 2010

JANUARY

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	8	8	8	8	8	8	8
2	4	4	6	5	8	15	12	12
3	12	8	8	5	8	8	8	8
4	8	8	6	8	8	8	8	8
5	8	8	6	4	8	8	7	7
6	8	3	0.8	0.2	6	6	6	6
7	6	3	0.1	5	5	15	15	12
8	12	12	5	2	5	18	18	16
9	12	8	0.8	4	8	8	8	8
10	12	12	8	8	8	8	12	10
11	10	10	10	6	8	15	15	15
12	12	12	0.2	8	18	18	15	11
13	11	11	3	2	8	8	8	15
14	15	15	12	5	8	8	8	8
15	12	12	5	2	12	15	14	12
16	12	10	10	5	14	19	14	12
17	12	12	10	8	14	14	14	12
18	12	12	6	5	8	8	8	14
19	8	8	6	5	5	4	4	5
20	5	5	2	2	4	4	2	2
21	4	4	3	1	3	3	3	3
22	3	3	3	5	5	5	5	5
23	5	5	5	5	5	5	5	5
24	5	5	5	5	5	5	5	5
25	8	8	6	6	12	15	10	10
26	10	12	10	14	14	14	14	12
27	12	12	10	6	8	8	8	14
28	14	14	14	5	8	8	8	10
29	10	10	8	8	8	8	8	8
30	12	12	4	5	8	8	8	8
31	8	8	8	8	8	8	8	8

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	8	8	3	8	8	8	8
2	10	10	8	8	8	8	8	8
3	8	8	8	8	8	8	8	8
4	8	8	8	8	8	8	8	8
5	8	10	10	14	14	14	14	14
6	12	12	5	6	6	6	5	5
7	5	5	5	3	5	5	5	5
8	5	8	8	8	8	8	6	6
9	8	8	6	6	8	8	8	8
10	8	8	8	5	5	5	5	8
11	8	12	12	8	8	8	8	5
12	5	5	15	8	8	8	12	12
13	12	12	10	10	10	12	12	12
14	12	12	12	14	18	18	16	14
15	14	10	10	16	16	16	16	15
16	14	14	14	15	18	18	16	14
17	14	14	14	14	16	18	16	6
18	8	12	5	8	15	15	15	6
19	12	12	5	8	18	20	18	16
20	16	16	12	14	14	14	17	14
21	14	14	14	7	15	16	16	12
22	12	12	12	14	18	20	18	14
23	14	14	8	10	14	20	18	15
24	14	14	12	12	20	22	18	14
25	14	14	12	14	17	17	17	16
26	14	14	14	15	18	18	16	14
27	12	12	12	14	18	20	20	14
28	14	14	8	10	14	18	18	12

MARCH

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	8	14	20	22	20	18
2	16	14	10	14	17	17	17	15
3	14	14	12	8	16	18	17	13
4	13	13	15	12	18	20	18	15
5	15	15	10	10	16	18	16	15
6	14	14	12	14	20	22	16	14
7	14	14	12	16	16	17	17	16
8	14	14	14	15	16	18	16	16
9	14	14	14	8	18	18	16	6
10	6	12	12	12	16	16	16	16
11	14	12	8	14	20	22	18	8
12	8	12	8	16	16	17	17	16
13	14	14	8	8	18	18	16	16
14	16	16	16	16	20	20	18	15
15	15	15	12	14	18	18	18	15
16	12	12	12	16	20	22	18	16
17	15	14	12	10	16	18	12	14
18	14	14	14	12	18	18	18	16
19	5	5	12	12	18	18	12	10
20	12	12	8	12	18	14	12	12
21	12	12	12	14	18	0.6	0.6	0.6
22	10	1	3	3	1	0.6	0.4	0.4
23	0.4	0.4	1.5	1.5	1	0.6	0.6	0.4
24	0.4	0.4	1.5	1.5	1	0.8	0.8	1
25	4	4	2	2	1.5	1.5	1.5	2
26	2	2	2	1	1	1.5	1.5	2
27	2	2	2	2	2	2	2	12
28	12	12	8	4	2	1.5	1.5	4
29	4	4	12	8	8	6	8	12
30	12	12	8	8	8	8	8	12
31	12	12	6	8	14	14	14	12

APRIL

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	8	14	20	22	20	18
2	16	14	10	14	17	17	17	15
3	14	14	12	8	16	18	17	13
4	13	13	15	12	18	20	18	15
5	15	15	10	10	16	18	16	15
6	14	14	12	14	20	22	16	14
7	14	14	12	16	16	17	17	16
8	14	14	14	15	16	18	16	16
9	14	14	14	8	18	18	16	6
10	6	12	12	12	16	16	16	16
11	14	12	8	14	20	22	18	8
12	8	12	8	16	16	17	17	16
13	14	14	8	8	18	18	16	16
14	16	16	16	16	20	20	18	15
15	15	15	12	14	18	18	18	15
16	12	12	12	16	20	22	18	16
17	15	14	12	10	16	18	12	14
18	14	14	14	12	18	18	18	16
19	5	5	12	12	18	18	12	10
20	12	12	8	12	18	14	12	12
21	12	12	12	14	18	0.6	0.6	0.6
22	10	1	3	3	1	0.6	0.4	0.4
23	0.4	0.4	1.5	1.5	1	0.6	0.6	0.4
24	0.4	0.4	1.5	1.5	1	0.8	0.8	1
25	4	4	2	2	1.5	1.5	1.5	2
26	2	2	2	1	1	1.5	1.5	2
27	2	2	2	2	2	2	2	12
28	12	12	8	4	2	1.5	1.5	4
29	4	4	12	8	8	6	8	12
30	12	12	8	8	8	8	8	12
31	12	12	6	8	14	14	14	12

MAY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	16	16	16	16	10
2	12	12	12	8	18	18	16	5
3	12	12	12	12	20	20	18	14
4	14	14	14	6	14	14	14	14
5	12	12	12	15	20	20	18	8
6	12	10	0.8	12	18	17	17	15
7	15	15	8	12	20	18	18	14
8	14	14	14	8	20	22	18	16
9	14	14	4	12	14	14	12	12
10	12	12	6	16	22	24	20	18
11	16	14	12	15	20	25	25	17
12	15	14	10	16	20	20	20	14
13	14	14	14	18	20	20	20	15
14	15	15	10	12	20	20	18	16
15	14	14	12	18	22	24	20	8
16	14	14	10	18	20	20	16	15
17	14	12	10	18	20	14	16	12
18	12	12	5	12	14	25	20	15
19	15	15	10	14	20	16	16	14
20	14	12	12	16	20	22	18	16
21	16	14	10	16	18	20	14	8
22	14	12	12	15	18	20	20	14
23	14	14	5	12	18	20	18	15
24	15	15	12	14	20	20	18	16
25	14	14	12	15	5	23	18	16
26	16	14	12	10	20	18	16	16
27	14	14	4	8	18	22	20	8
28	14	14	5	12	20	22	20	14
29	14	14	14	12	20	20	16	14
30	14	12	12	18	20	24	18	12
31	12	12	10	14	14	17	17	16

JUNE								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	12	10	14	18	20	6	8
2	14	8	3	14	18	25	8	10
3	14	14	5	12	18	18	16	14
4	6	12	6	10	18	24	18	16
5	14	12	10	14	18	22	20	16
6	14	14	4	12	20	23	20	14
7	14	5	5	18	20	22	20	14
8	14	12	5	10	14	16	8	12
9	12	12	12	16	20	24	18	12
10	10	10	10	14	14	17	17	15
11	14	14	10	14	18	20	18	14
12	14	14	8	12	16	20	20	12
13	15	12	0.6	0.4	16	20	14	14
14	12	12	5	14	20	24	18	16
15	14	14	8	16	18	18	18	6
16	12	12	4	12	18	22	12	12
17	12	12	3	12	18	20	22	14
18	14	14	6	12	14	14	14	12
19	12	12	12	16	22	24	20	18
20	16	16	14	17	17	14	14	14
21	14	14	10	12	18	18	16	16
22	14	14	4	12	20	22	18	15
23	15	15	6	12	14	14	14	14
24	14	14	12	15	20	22	18	16
25	14	14	12	12	16	16	16	16
26	14	12	8	10	18	20	18	16
27	16	14	5	12	18	22	18	14
28	14	14	14	14	20	20	20	8
29	12	12	14	17	22	24	20	18
30	16	14	8	12	16	16	16	15

JULY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	14	10	12	18	20	20	14
2	14	8	10	14	20	22	20	14
3	14	12	12	14	16	16	16	16
4	14	12	14	18	22	24	18	8
5	12	12	6	6	16	20	20	18
6	14	14	12	16	20	22	20	16
7	16	16	8	16	20	5	14	5
8	12	12	6	12	14	14	14	14
9	12	12	8	14	20	8	18	12
10	12	10	8	10	18	20	20	16
11	14	14	6	8	16	18	16	14
12	14	14	5	14	20	22	18	14
13	12	3	4	10	14	14	14	8
14	8	12	8	15	20	24	18	16
15	14	12	8	14	16	20	20	16
16	14	12	13	5	4	18	12	8
17	812	12	5	14	5	20	18	12
18	14	12	8	10	14	16	16	16
19	14	14	8	14	20	25	18	16
20	14	12	10	16	22	24	20	17
21	14	14	12	16	20	22	20	14
22	14	14	12	18	20	22	22	14
23	14	14	12	12	16	18	18	14
24	14	14	12	18	24	25	20	16
25	16	16	12	14	17	17	17	16
26	14	14	14	18	20	20	20	14
27	14	14	14	18	20	20	20	14
28	12	12	6	10	16	16	16	14
29	14	14	12	14	20	22	18	16
30	16	14	10	14	14	19	19	16
31	14	14	6	14	20	20	20	15

AUGUST								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	11	11	11	14	18	22	20	15
2	15	15	5	14	20	20	20	16
3	14	14	12	12	18	24	18	16
4	14	10	10	12	16	20	20	16
5	14	14	12	16	20	22	20	14
6	11	11	11	16	20	24	24	18
7	15	14	10	10	20	20	18	14
8	12	12	12	5	18	20	20	8
9	8	10	8	14	20	20	20	14
10	14	12	4	6	16	18	18	14
11	14	14	14	12	18	20	14	6
12	12	6	8	12	5	18	16	14
13	12	12	5	5	12	20	20	12
14	12	12	12	16	21	21	21	16
15	14	14	2.5	12	20	20	20	13
16	13	13	13	14	18	20	18	15
17	15	10	6	6	10	14	14	14
18	12	12	4	8	20	20	6	14
19	12	12	8	14	19	24	24	16
20	14	14	12	6	20	20	18	14
21	14	14	14	5	16	5	12	12
22	12	12	5	7	18	20	20	14
23	6	5	5	14	22	24	24	16
24	14	10	10	13	17	17	17	14
25	14	14	12	16	18	20	20	14
26	11	11	5	5	14	20	18	15
27	15	15	14	16	22	24	20	16
28	14	14	5	18	22	22	22	14
29	14	14	8	5	8	20	18	14
30	14	14	12	18	20	20	20	16
31	14	14	5	12	20	22	20	15

SEPTEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	6	6	20	25	4	10
2	14	14	8	14	20	24	18	16
3	14	12	8	12	12	16	16	16
4	14	12	10	16	20	20	20	14
5	14	4	5	14	20	22	18	15
6	14	14	12	14	14	14	14	14
7	12	12	12	14	20	22	18	16
8	14	14	8	12	14	17	17	16
9	16	12	12	7	18	20	20	13
10	13	13	13	16	18	20	18	15
11	15	15	12	14	16	16	8	6
12	6	12	6	14	20	24	20	8
13	10	10	10	14	17	17	17	16
14	14	14	12	15	18	20	20	13
15	13	13	13	14	18	18	6	15
16	15	5	2	10	16	22	20	16
17	14	5	2	16	20	25	22	16
18	14	12	12	12	17	17	5	14
19	12	12	12	18	20	20	16	14
20	12	12	12	16	16	22	20	15
21	15	14	14	14	20	20	18	16
22	14	12	12	18	22	25	22	12
23	6	6	6	2	12	15	15	14
24	14	6	12	12	20	20	20	11
25	11	3	11	14	20	22	20	15
26	15	15	12	18	20	24	20	8
27	14	12	4	16	6	22	22	14
28	6	6	6	12	12	17	17	14
29	14	14	12	16	25	25	14	14
30	11	11	11	16	20	20	16	14

OCTOBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	8	4	8	20	20	18	16
2	14	14	12	16	22	22	22	16
3	16	14	3	11	5	12	12	12
4	12	12	12	14	20	8	8	14
5	14	14	12	14	20	22	18	14
6	14	14	10	16	20	20	8	12
7	5	12	12	18	22	25	12	12
8	12	12	5	12	14	8	14	14
9	12	12	12	14	18	20	20	14
10	14	14	10	12	22	24	18	6
11	14	14	6	16	25	25	20	16
12	14	14	12	18	22	25	22	14
13	14	14	16	16	16	14	22	8
14	14	14	14	18	22	25	8	14
15	14	14	14	18	20	25	20	14
16	14	14	6	16	20	24	20	16
17	12	5	0.6	14	22	25	20	14
18	14	14	3	18	22	22	14	14
19	14	14	4	14	22	22	16	15
20	13	13	4	4	18	22	20	14
21	14	14	1	18	22	25	18	16
22	14	14	5	14	20	22	20	14
23	14	14	14	18	22	22	20	15
24	14	14	14	15	20	20	15	15
25	5	12	12	18	20	22	20	14
26	14	14	10	14	14	5	14	14
27	12	5	5	14	20	20	18	14
28	14	14	5	14	20	24	20	14
29	14	14	14	16	12	18	18	15
30	15	14	14	14	20	24	16	14
31	14	14	6	10	20	24	18	15

NOVEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	5	12	12	15	22	24	12	12
2	12	12	12	18	24	24	22	16
3	14	14	0.6	3	8	14	10	14
4	12	12	5	8	8	10	10	10
5	12	12	6	14	18	20	18	14
6	12	12	4	5	18	22	16	14
7	12	12	2	12	22	22	16	12
8	12	12	14	14	18	18	16	13
9	13	13	4	8	18	20	16	14
10	14	14	12	18	20	22	18	16
11	14	12	12	8	18	24	16	14
12	14	12	3	10	18	22	18	14
13	14	14	14	14	20	20	18	14
14	14	14	5	16	20	24	18	15
15	14	14	8	16	24	25	16	15
16	14	8	5	18	22	22	22	16
17	14	12	10	10	16	20	10	16
18	14	14	14	15	18	20	18	14
19	14	14	5	8	20	22	20	14
20	14	14	2	10	14	14	12	12
21	12	12	11	15	18	20	18	16
22	14	14	10	14	14	17	15	12
23	12	12	12	8	20	20	18	14
24	14	14	4	16	20	22	18	14
25	14	14	14	15	18	20	16	14
26	12	12	12	15	18	18	16	14
27	14	12	12	16	18	15	14	12
28	12	12	12	14	18	20	16	14
29	14	14	10	8	18	22	20	14
30	14	14	12	14	14	20	16	16

DECEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	12	12	16	18	18	16	12
2	12	12	12	16	18	20	18	15
3	14	14	12	14	15	20	18	16
4	14	14	10	14	18	22	20	14
5	14	14	8	14	14	14	14	14
6	12	12	6	6	8	14	10	10
7	10	8	8	5	5	8	6	12
8	12	12	5	5	15	18	16	15
9	14	12	6	14	18	8	8	8
10	8	8	6	5	6	8	8	8
11	8	8	5	5	5	6	5	6
12	6	6	0.2	0.8	6	8	6	6
13	6	4	0.2	1.6	6	6	6	6
14	6	6	2	5	5	6	8	8
15	8	8	5	4	4	8	8	8
16	8	8	5	5	6	6	5	5
17	5	5	5	0.8	5	5	4	4
18	4	4	3	5	6	8	8	8
19	8	8	3	5	5	8	8	8
20	8	8	5	8	8	8	8	8
21	8	5	5	5	5	5	4	4
22	4	6	6	5	5	5	4	10
23	10	10	6	8	12	8	15	14
24	14	12	6	8	14	8	8	8
25	8	8	8	6	6	8	8	8
26	8	8	8	8	8	8	6	8
27	8	8	8	4	5	5	4	10
28	10	10	0.3	4	6	8	6	12
29	12	12	8	8	8	8	5	14
30	14	14	8	4	6	6	8	8
31	8	8	8	3	3	2	15	3

KUMASI 2011

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	3	3	3	2	2	2	1.5	1.5
2	1	1	1	2	2	2	2	2
3	2	2	1.5	1	4	2	1.5	1.5
4	1.5	4	2	2	2	2	3	2
5	2	4	2	2	2	2	2	2
6	2	2	2	2	3	3	2	3
7	3	3	0.2	0.3	2	8	8	5
8	5	5	2	4	5	3	2.5	2.5
9	5	3	1	1.6	2	3	3	3
10	3	4	2	2	2	1.5	1.5	1.5
11	15	1.5	1.5	0.8	0.7	0.5	0.4	0.4
12	0.4	0.3	0.5	0.6	0.6	0.5	0.4	0.4
13	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.5
14	0.2	0.4	1	0.8	0.8	0.6	0.6	0.6
15	0.5	0.3	0.3	0.5	0.8	0.8	0.6	0.6
16	0.6	0.4	0.4	1.6	1.8	1.6	1.4	2
17	2	2	1.5	3	4	4	3	3
18	3	3	1	1.2	2	4	4	4
19	2	4	4	0.8	2	2	2	2
20	2	4	2	2	2.5	3	2	2
21	2	2	2	1.8	1.8	2	1.6	2
22	2	2	3	2	4	4	4	4
23	4	4	4	8	8	8	8	14
24	14	14	8	8	14	12	12	5
25	12	12	12	14	16	16	16	14
26	14	14	14	8	8	6	5	14
27	14	14	14	12	18	18	16	12
28	12	12	5	12	18	18	18	14
29	14	14	14	14	20	20	16	14
30	14	12	12	12	18	22	18	16
31	14	14	12	10	10	10	15	14

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	10	16	20	20	20	5
2	12	12	12	14	18	25	20	16
3	14	14	14	14	14	10	10	12
4	12	12	14	12	18	18	16	14
5	14	14	10	2	5	5	4	5
6	5	5	5	8	8	8	8	8
7	5	5	5	8	6	6	6	6
8	6	8	8	5	8	8	8	6
9	6	8	8	12	18	22	18	15
10	15	14	14	5	8	8	6	12
11	14	14	14	6	16	12	12	12
12	12	12	12	12	18	22	18	12
13	14	14	12	16	20	23	20	15
14	13	12	12	15	20	20	16	14
15	5	14	14	8	8	8	6	6
16	6	6	5	14	15	20	20	14
17	14	14	14	14	18	20	18	14
18	14	14	14	14	14	14	14	14
19	12	12	12	14	18	20	18	16
20	16	16	5	12	16	18	18	16
21	15	14	14	15	18	20	20	16
22	14	14	14	16	20	22	15	14
23	14	14	6	16	24	26	18	16
24	14	14	14	4	20	24	20	14
25	14	14	14	15	20	15	12	12
26	12	12	12	16	18	6	18	14
27	12	12	12	12	16	16	6	14
28	12	12	14	14	24	24	20	16

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	8	18	16	14
2	14	14	12	8	22	24	14	14
3	14	14	14	10	18	22	20	16
4	8	8	12	14	20	22	20	18
5	15	15	6	14	16	16	16	15
6	14	14	8	18	18	18	18	14
7	14	14	12	12	15	17	17	14
8	12	12	14	15	18	20	18	14
9	10	10	10	16	20	24	18	14
10	14	14	14	14	16	16	16	15
11	14	12	12	16	18	18	18	16
12	16	16	16	16	16	18	16	14
13	12	12	14	6	18	20	20	14
14	14	14	14	16	20	22	18	14
15	14	14	6	18	22	22	22	16
16	12	12	12	14	20	22	18	13
17	13	13	10	14	16	18	16	14
18	14	14	14	16	20	20	18	8
19	15	15	6	15	18	22	15	4
20	14	14	10	18	22	22	22	12
21	12	12	6	12	20	24	16	8
22	6	6	8	14	18	18	14	6
23	14	14	4	14	20	22	18	15
24	6	12	12	16	20	22	12	12
25	14	14	6	16	18	18	16	6
26	12	12	6	6	18	22	18	16
27	14	14	14	18	18	18	16	14
28	14	14	12	14	18	22	20	14
29	12	12	12	16	22	24	14	14
30	14	14	14	16	16	20	20	16
31	14	14	0.5	16	22	22	18	14

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	14	14	17	20	20	16
2	14	14	10	15	22	22	20	5
3	12	12	12	16	18	22	14	14
4	14	14	14	16	16	6	12	12
5	12	12	8	14	20	22	18	16
6	14	14	10	14	18	18	18	16
7	14	14	10	16	18	18	16	13
8	13	13	13	16	18	20	16	12
9	12	12	12	14	18	18	18	14
10	12	12	12	14	18	22	18	14
11	14	12	8	14	19	17	22	18
12	14	14	12	18	20	22	5	13
13	5	13	3	4	18	18	16	14
14	14	14	14	14	14	18	8	14
15	12	12	8	14	20	22	18	16
16	16	16	16	18	22	22	22	18
17	14	14	6	18	22	22	18	3
18	3	11	11	14	18	22	18	14
19	14	14	5	14	20	20	20	16
20	14	14	8	20	25	25	22	16
21	16	16	14	16	16	22	22	16
22	16	16	16	15	20	20	20	16
23	16	16	16	18	20	22	15	14
24	14	14	12	16	18	20	20	16
25	14	14	14	20	25	26	20	16
26	14	14	14	18	26	26	18	14
27	13	13	13	15	22	22	20	13
28	8	13	13	16	20	24	15	6
29	6	12	10	16	16	20	20	16
30	14	14	14	16	22	22	20	16

MAY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	20	22	22	16
2	16	16	16	20	20	22	18	13
3	13	13	5	14	18	22	18	16
4	14	14	14	16	16	16	16	16
5	14	14	8	18	24	25	20	16
6	16	16	14	17	22	22	22	17
7	17	17	17	20	24	24	24	13
8	13	13	13	16	20	22	16	14
9	14	14	14	16	25	25	20	16
10	14	14	14	18	25	5	16	16
11	16	16	10	14	22	22	22	16
12	16	16	18	20	22	22	18	12
13	12	12	5	16	20	22	5	14
14	14	14	10	18	22	14	14	14
15	12	12	12	18	20	20	18	16
16	16	16	12	15	18	22	18	16
17	16	16	16	20	22	22	15	15
18	11	11	4	14	18	22	20	16
19	14	14	10	16	16	18	18	14
20	14	12	5	18	24	24	20	16
21	16	16	16	16	23	23	14	14
22	14	14	14	16	19	19	19	14
23	14	14	8	14	18	24	18	15
24	14	14	14	18	18	18	18	16
25	14	14	12	16	18	24	18	16
26	16	16	10	14	22	22	22	12
27	2	6	8	18	18	18	16	4
28	12	12	12	20	25	5	8	14
29	14	14	2	14	18	18	18	16
30	14	14	12	18	22	20	14	14
31	12	10	10	14	14	19	15	14

JUNE

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	16	16	24	24	20	12
2	12	12	10	16	20	24	18	14
3	14	14	10	14	20	8	12	12
4	12	12	12	18	20	26	22	16
5	6	8	8	10	18	25	24	14
6	12	12	14	18	20	20	18	16
7	16	14	12	14	18	12	5	10
8	12	12	5	8	20	22	12	5
9	12	12	8	18	24	24	20	16
10	16	14	0.2	12	22	22	18	12
11	12	12	14	18	25	25	18	14
12	14	14	14	16	20	5	5	14
13	14	14	3	14	20	25	24	16
14	14	12	8	16	20	22	22	18
15	18	14	10	16	18	20	12	12
16	12	12	14	14	18	23	18	16
17	14	14	10	16	20	24	15	6
18	4	14	16	8	18	26	22	16
19	14	14	12	16	22	22	14	14
20	14	14	10	12	20	22	18	14
21	14	12	14	20	20	22	20	14
22	14	14	10	14	20	22	22	16
23	14	14	8	10	20	22	16	10
24	12	12	14	16	20	40	5	10
25	10	10	8	10	18	22	18	14
26	12	12	8	12	20	20	5	10
27	12	12	10	14	18	24	20	15
28	14	14	6	12	18	20	20	16
29	14	12	8	8	12	18	18	16
30	14	12	8	8	14	18	18	8

JULY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	5	5	14	20	18	16
2	16	14	8	14	16	20	18	15
3	14	12	6	12	18	18	8	5
4	14	12	6	8	20	22	20	16
5	16	8	8	12	18	20	20	14
6	12	10	5	8	15	20	20	8
7	14	14	8	12	18	20	18	4
8	14	14	6	12	18	18	16	16
9	12	12	12	16	20	20	20	16
10	16	16	8	14	18	20	18	16
11	16	14	12	14	18	20	20	16
12	16	14	10	12	18	20	20	15
13	15	15	8	16	16	20	18	14
14	12	12	8	8	16	20	20	16
15	16	12	5	8	16	18	16	14
16	14	12	5	5	18	20	18	16
17	16	16	8	16	20	20	18	16
18	6	14	6	6	14	18	18	14
19	12	12	0.5	8	20	20	20	16
20	16	14	8	14	18	18	16	14
21	14	14	6	8	20	20	20	16
22	16	14	10	14	16	18	20	16
23	14	14	12	14	20	20	20	14
24	12	8	8	14	18	12	16	14
25	14	14	10	12	18	18	14	14
26	14	14	8	14	18	18	18	16
27	14	12	10	14	20	20	20	16
28	16	16	14	12	18	18	18	14
29	12	12	12	8	18	20	18	16
30	8	12	7	10	18	24	18	14
31	14	10	12	18	20	20	20	16

AUGUST

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	8	14	18	20	18	15
2	14	14	14	8	12	8	14	14
3	14	12	12	14	8	20	20	16
4	16	12	8	12	16	22	16	8
5	12	12	12	18	20	20	20	16
6	14	12	6	8	18	20	20	16
7	15	15	12	10	8	12	14	14
8	14	14	12	8	14	16	14	14
9	14	12	10	8	17	18	16	14
10	12	12	12	8	18	20	20	14
11	14	14	12	8	16	20	20	16
12	16	16	8	10	16	16	16	14
13	12	6	6	12	18	18	6	8
14	12	12	6	8	14	24	18	16
15	14	14	12	14	18	20	20	14
16	14	14	14	12	18	18	18	8
17	6	12	6	12	14	16	16	14
18	12	12	6	14	20	20	20	20
19	16	16	12	12	18	18	16	14
20	14	14	0.5	2.5	16	22	22	12
21	12	12	0.1	4	16	20	18	15
22	15	14	6	12	18	20	18	16
23	12	12	12	8	14	18	18	16
24	12	12	12	14	16	18	14	14
25	12	12	12	16	20	20	16	12
26	12	12	12	12	18	20	14	14
27	12	12	8	14	16	16	18	16
28	5	6	5	5	8	8	8	12
29	12	8	8	6	20	18	18	12
30	12	12	8	14	18	20	20	16
31	16	16	16	12	18	22	20	6

SEPTEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	6	10	16	22	20	8
2	14	14	14	16	16	18	18	8
3	8	12	4	18	24	25	24	16
4	12	8	3	14	17	20	20	16
5	14	10	14	14	18	20	18	14
6	14	14	8	14	18	20	20	16
7	14	12	12	16	20	22	20	16
8	14	12	8	12	18	20	14	14
9	14	12	12	14	20	24	22	16
10	16	16	18	16	14	18	18	14
11	14	14	14	14	20	20	18	18
12	16	12	8	12	18	20	20	16
13	16	12	10	14	18	12	10	6
14	14	14	12	14	17	20	5	16
15	16	10	10	12	14	16	18	14
16	14	14	5	12	14	16	16	14
17	14	12	12	16	20	20	20	8
18	16	14	14	5	22	27	18	16
19	14	12	12	14	16	20	20	12
20	12	10	8	8	18	20	12	5
21	12	12	12	14	14	14	12	12
22	12	12	5	16	20	22	22	18
23	16	14	10	12	20	25	20	14
24	14	14	14	16	8	18	16	15
25	14	14	12	12	18	22	22	16
26	16	16	16	8	20	12	14	14
27	12	0.4	5	5	12	20	20	16
28	14	8	8	8	16	24	6	14
29	12	6	8	16	23	25	20	15
30	14	14	12	14	20	8	14	14

OCTOBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	12	12	6	18	20	20	16
2	12	12	12	16	20	25	20	16
3	16	16	16	18	22	18	10	14
4	12	12	6	16	16	22	22	14
5	14	14	16	16	20	22	12	12
6	12	12	12	14	16	16	8	14
7	14	14	12	18	22	22	20	16
8	14	6	6	16	22	8	20	6
9	12	12	12	14	20	20	5	14
10	14	8	8	14	18	22	12	5
11	12	5	12	18	18	18	18	16
12	14	12	12	6	16	18	20	16
13	16	8	8	8	27	27	22	8
14	6	6	6	16	24	24	16	10
15	10	12	6	16	18	18	18	14
16	12	12	12	18	22	25	22	18
17	14	14	12	18	22	22	20	8
18	14	14	8	12	20	20	14	14
19	14	12	12	17	22	22	20	14
20	14	14	10	8	18	20	16	14
21	4	14	14	16	20	20	18	16
22	14	14	12	16	20	20	20	6
23	12	10	7	15	25	25	24	14
24	12	12	6	8	20	20	14	5
25	6	10	8	8	22	22	5	14
26	14	5	11	12	18	18	16	16
27	14	8	8	16	22	22	20	16
28	16	14	10	10	18	20	18	14
29	14	12	12	14	20	20	16	12
30	12	12	6	12	18	20	20	12
31	5	12	6	12	16	20	18	18

NOVEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	14	8	14	22	22	20	14
2	14	14	10	10	16	20	14	14
3	14	14	14	14	20	20	20	14
4	12	10	12	14	20	24	20	13
5	13	13	5	16	20	20	18	16
6	12	12	8	16	20	22	20	14
7	14	14	12	14	16	20	16	14
8	14	14	12	18	20	22	22	16
9	16	14	10	14	20	24	20	11
10	11	11	11	14	16	20	20	16
11	14	14	6	14	20	24	20	16
12	16	16	16	16	20	18	16	14
13	14	14	12	14	18	22	22	14
14	14	14	10	14	20	22	20	14
15	14	14	14	16	16	22	22	15
16	15	14	8	12	20	22	18	16
17	14	12	4	10	18	20	12	10
18	10	10	8	16	20	22	22	18
19	14	14	4	15	18	20	18	13
20	13	13	5	10	20	20	18	15
21	15	15	10	14	16	22	20	16
22	16	14	10	14	20	14	10	14
23	14	14	12	14	18	22	14	12
24	12	10	6	8	20	20	15	14
25	14	14	6	14	20	20	20	15
26	14	14	6	14	18	22	18	16
27	14	14	10	10	18	18	14	14
28	14	12	12	12	20	22	18	12
29	14	12	10	16	18	20	20	16
30	12	14	4	14	18	20	16	14

DECEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	5	14	20	20	16	14
2	14	10	0.6	8	8	18	16	14
3	14	14	8	8	8	16	14	14
4	14	14	12	16	8	18	18	15
5	14	14	3	10	14	16	16	14
6	14	14	12	14	16	18	16	14
7	14	12	10	12	12	13	10	12
8	12	12	12	14	15	18	16	12
9	12	12	6	8	8	8	8	8
10	8	8	4	6	6	8	8	14
11	14	14	4	12	14	8	8	10
12	10	10	5	3	3	2.5	2.5	5
13	6	6	4	2	2	2	1.6	1.6
14	1.6	1.6	1.5	1.6	2.4	3	4	4
15	4	4	2	16	2	3	3	3
16	5	5	4	1.2	3	8	6	6
17	6	6	1.2	1.6	4	5	5	5
18	5	6	3	2.5	5	5	5	5
19	5	5	0.2	0.8	5	8	6	6
20	6	6	6	6	8	8	6	10
21	10	10	8	6	8	8	8	12
22	12	12	8	6	6	5	5	8
23	8	8	8	8	8	8	8	6
24	6	6	5	8	8	8	8	8
25	8	8	6	3	8	8	8	6
26	8	6	6	3	8	8	8	8
27	6	8	8	5	5	5	4.5	8
28	8	8	6	3	8	8	4	4
29	8	4	0.1	4	7	7	5	5
30	4	5	5	8	8	8	8	8
31	5	5	4	8	8	8	8	8

NAVRONGO 2010

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	4	4	4	4	6	6	6	6
2	6	6	6	6	6	6	6	6
3	6	6	6	6	8	8	8	8
4	8	8	8	8	8	8	8	8
5	8	8	8	9	9	9	9	9
6	9	9	9	9	9	9	9	9
7	9	9	9	9	7	7	7	7
8	7	7	7	7	9	9	9	9
9	9	9	9	9	9	9	9	9
10	9	9	9	9	9	9	9	9
11	9	9	9	9	9	9	9	9
12	9	9	9	9	9	9	9	9
13	9	9	9	9	9	9	9	9
14	9	9	9	9	9	9	9	9
15	9	9	9	9	9	9	9	9
16	9	9	9	9	9	9	9	9
17	9	9	9	9	9	9	9	9
18	9	9	9	4	4	2.5	2.5	4
19	4	4	4	2	2	2	2	2
20	2	2	2	2	2	2	2	2
21	2	2	2	6	6	6	6	6
22	6	6	6	6	6	6	6	6
23	6	6	6	8	9	9	9	9
24	9	9	9	9	9	9	9	9
25	9	9	9	9	9	9	9	9
26	9	9	9	9	9	9	9	9
27	9	9	9	9	9	9	9	9
28	9	9	9	9	9	9	9	9
29	9	9	9	9	9	9	9	9
30	9	9	9	9	9	9	9	9
31	9	9	9	9	9	9	9	9

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	9	9	9	9	9	9	9	9
2	9	9	9	9	9	9	9	9
3	9	9	9	9	9	9	9	9
4	9	9	9	9	9	9	9	9
5	9	9	9	4	4	4	4	4
6	4	4	4	4	4	4	4	4
7	4	4	4	1	2	4	4	4
8	4	4	4	4	4	6	6	6
9	6	6	6	6	6	6	6	6
10	6	6	6	6	6	6	6	6
11	6	6	6	6	6	6	6	6
12	6	6	6	6	6	6	6	6
13	6	12	12	12	12	12	6	12
14	12	12	12	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	9	9	9	9	9
18	9	9	9	12	12	12	12	12
19	12	12	12	12	12	12	12	12
20	12	12	12	12	12	12	12	12
21	12	12	12	6	6	6	6	6
22	6	6	6	6	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	12	12	9	9	12	12
25	12	12	12	9	9	9	9	12
26	12	12	12	12	10	10	10	10
27	12	12	12	9	9	12	12	12
28	12	12	12	6	6	6	6	6
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	6	6	6	6	6	6	6	6
2	6	6	6	6	6	6	6	6
3	6	6	6	6	6	6	6	6
4	6	6	6	6	6	6	6	6
5	6	6	6	3	3	3	3	3
6	3	3	3	3	3	3	3	3
7	3	3	4.5	6	6	6	6	6
8	6	6	6	6	6	6	6	6
9	6	6	6	6	6	6	6	6
10	6	6	6	9	9	9	9	9
11	9	9	9	9	9	9	9	12
12	9	12	12	12	12	12	12	12
13	12	12	12	6	6	6	6	6
14	6	6	6	6	6	6	6	6
15	6	6	6	6	6	6	6	6
16	6	6	6	6	6	6	6	6
17	12	12	12	12	12	12	12	12
18	12	12	12	12	12	12	12	12
19	12	12	12	12	12	12	12	12
20	12	6	0.3	0.3	0.3	0.3	0.3	0.5
21	0.5	0.5	0.8	0.5	0.4	0.4	0.4	0.4
22	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
23	0.4	0.6	0.6	0.6	0.6	0.7	0.8	0.8
24	0.8	0.8	0.8	0.8	1	1	1	1
25	1	1	4	4	4	4	4	4
26	4	4	4	4	4	3.5	3.5	4
27	4	4	4	6	8	8	8	8
28	8	8	8	8	8	4	4	4
29	4	4	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3
31	3	3	5	5	5	5	5	5

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	5	5	5	5	5	5	5	5
2	5	5	5	5	4	4	4	4
3	4	4	4	4	5	5	5	5
4	7	7	7	7	8	8	8	8
5	8	8	8	8	8	8	8	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	9	9	9
9	9	9	9	12	12	12	12	12
10	12	12	12	12	12	12	9	9
11	9	9	9	9	9	9	9	9
12	9	9	9	9	9	9	9	9
13	9	9	9	9	9	9	9	9
14	8	12	12	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	12	18	12	12	12
18	12	14	12	14	14	14	14	14
19	14	14	14	14	14	14	14	14
20	14	4	14	14	9	8	4	4
21	4	12	4	10	10	12	12	12
22	12	9	12	12	12	12	12	12
23	9	12	12	12	12	12	12	12
24	12	12	12	12	12	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	12	12	12	12
27	12	12	10	10	10	12	12	12
28	12	12	12	12	12	12	12	12
29	12	12	12	12	12	12	12	12
30	9	12	12	12	12	12	12	12
31								

MAY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	10	8
2	12	12	12	12	12	12	12	12
3	12	12	12	12	12	12	12	12
4	12	12	12	12	12	12	12	12
5	12	12	12	12	12	12	12	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	12	12	12	12	12	12	12	12
11	12	12	12	12	12	12	12	12
12	9	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	12	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	12	12	12	12	12
18	12	12	12	12	12	12	12	12
19	12	12	12	12	12	12	12	9
20	12	9	12	12	12	12	12	12
21	12	9	12	12	12	12	12	12
22	12	12	12	12	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	12	12	12	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	12	12	12	12
27	12	12	12	12	12	12	12	12
28	12	12	12	12	12	12	12	12
29	12	12	12	12	12	12	12	12
30	12	12	12	12	12	12	12	12
31	12	12	12	12	12	12	12	12

JUNE

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	6	11	12	12	12	12	12
2	12	12	12	12	12	12	12	12
3	12	12	12	12	12	12	12	12
4	12	9	9	12	12	12	12	12
5	12	12	12	12	12	12	12	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	12	7	10	12	12	12	12	12
11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	12	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	7	12	12	12	12	12	12	12
18	12	12	12	12	12	12	12	12
19	12	12	12	12	12	12	12	12
20	12	12	12	12	12	12	12	12
21	12	12	12	12	12	12	12	12
22	12	12	12	10	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	12	12	12	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	6	12	12	12	12
27	12	12	12	12	12	12	12	12
28	12	12	12	12	12	12	12	12
29	12	12	12	12	12	12	12	12
30	12	12	12	12	12	12	12	12
31								

JULY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	12	12
2	12	12	12	12	12	12	9	12
3	12	12	12	12	12	12	12	12
4	12	12	12	12	12	12	12	12
5	12	12	12	12	12	12	9	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	10	12	12	12	12	12	12	12
11	12	12	12	12	12	12	10	9
12	9	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	12	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	9	9	12	12
17	12	12	12	12	12	12	12	12
18	12	12	12	12	12	12	12	12
19	12	12	12	12	12	12	12	12
20	12	9	12	12	12	12	12	12
21	12	12	12	10	12	12	12	12
22	12	12	12	12	12	12	9	10
23	9	9	9	12	12	12	12	12
24	12	12	8	12	12	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	12	12	12	12
27	12	12	12	12	12	12	12	12
28	12	12	12	12	12	12	12	12
29	12	12	12	12	12	12	12	12
30	12	12	9	10	12	12	12	12
31	12	12	12	12	12	12	12	12

AUGUST

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	12	12
2	12	12	12	12	12	12	12	12
3	12	12	12	12	12	12	9	12
4	12	12	12	12	12	12	12	12
5	12	12	12	12	12	12	12	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	10	14	14	14
10	12	12	12	14	12	12	12	12
11	12	9	9	12	12	12	12	12
12	12	12	12	12	12	10	12	12
13	12	12	10	12	12	12	12	12
14	12	12	12	12	12	9	12	12
15	12	12	12	10	12	12	12	12
16	12	12	6	12	12	12	12	12
17	12	12	12	12	12	12	12	12
18	12	12	12	12	12	12	9	12
19	12	12	12	12	12	12	12	12
20	12	12	12	12	12	12	10	9
21	12	9	12	6	12	12	12	12
22	12	12	12	12	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	12	12	14	14	14	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	9	12	12	12
27	12	12	12	12	12	12	12	12
28	12	12	12	12	12	12	12	12
29	12	12	12	12	12	12	12	12
30	12	12	12	12	12	12	12	10
31	9	12	10	10	12	12	12	12

SEPTEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	9	12	12	12	12	12	12
2	12	12	12	12	12	12	12	12
3	12	12	4	9	12	12	12	12
4	12	12	12	12	12	12	12	12
5	12	12	6	12	12	9	6	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	9	10	12	12	12	12	9	12
9	12	12	12	12	9	12	12	12
10	12	12	12	12	12	12	12	12
11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	9	12	12	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	12	12	12	12	12
18	12	12	12	12	12	12	12	12
19	12	12	12	12	12	12	12	12
20	12	12	12	12	6	12	12	12
21	12	12	12	12	12	12	12	12
22	12	12	12	12	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	12	12	12	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	12	12	12	12
27	12	12	12	12	12	12	12	12
28	12	12	12	12	12	12	12	12
29	12	12	12	12	12	12	12	12
30	12	12	12	12	12	12	12	12
31								

OCTOBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	13	12	12	12	12	12
2	12	12	12	12	12	12	12	12
3	12	12	12	12	12	12	12	12
4	12	12	12	14	14	14	14	12
5	12	12	12	12	12	12	12	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	14	14	14	14	12
9	12	12	12	12	12	12	12	12
10	12	12	12	12	14	14	12	12
11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	9	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	16	16	16	9	12
17	12	12	12	12	12	12	12	12
18	12	12	12	12	12	14	14	14
19	14	14	10	12	12	12	12	12
20	12	12	12	10	12	12	12	12
21	12	12	12	12	12	14	14	14
22	14	14	14	14	14	14	14	14
23	14	14	14	14	14	14	14	14
24	14	14	14	16	16	16	14	12
25	12	12	12	12	12	14	14	14
26	14	14	6	10	12	12	12	12
27	12	12	12	12	12	14	14	14
28	14	14	14	14	14	14	14	14
29	14	14	14	16	16	16	16	14
30	14	14	14	14	14	14	14	14
31	14	14	14	14	14	12	12	12

NOVEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	12	12
2	12	12	12	8	8	8	8	8
3	8	8	8	8	8	7	5	5
4	5	5	5	5	5	5	5	5
5	15	15	15	5	5	5	5	5
6	5	5	5	8	8	8	8	8
7	8	8	8	8	8	8	8	8
8	8	8	8	8	14	14	14	14
9	12	12	12	12	12	14	14	14
10	14	14	14	14	14	14	14	14
11	14	14	14	14	14	14	14	14
12	14	14	14	8	8	8	8	8
13	8	8	8	8	8	8	8	8
14	8	8	8	8	8	8	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	6	9	9	9	9
18	8	8	8	8	16	16	16	16
19	16	16	16	6	6	6	6	6
20	6	6	6	6	12	12	12	12
21	12	12	12	12	12	12	12	12
22	12	12	12	6	6	6	6	12
23	12	12	12	12	12	12	12	12
24	12	12	12	12	8	8	8	8
25	8	8	8	9	9	9	9	9
26	9	9	9	9	9	9	9	9
27	9	9	9	9	9	9	9	9
28	9	9	9	4	8	8	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	8	12	12	12	12
31								

DECEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	9	9	9	9	9
2	9	9	9	9	9	9	6	6
3	6	6	6	6	6	6	6	6
4	6	6	6	6	6	6	6	6
5	6	6	7	7	7	7	7	7
6	7	7	7	5	8	8	8	8
7	8	8	8	8	8	8	8	8
8	8	8	8	5	5	5	5	5
9	5	5	5	5	5	5	5	5
10	5	5	8	8	8	8	8	8
11	8	8	8	8	8	8	8	8
12	8	8	8	8	8	8	8	8
13	8	8	8	4	4	6	6	6
14	6	6	6	6	6	6	6	6
15	6	6	6	7	8	8	8	8
16	8	8	8	6	8	8	8	8
17	8	8	8	8	8	8	8	8
18	8	8	8	4	9	9	9	9
19	9	9	9	8	8	8	8	8
20	8	8	8	8	8	6	6	6
21	6	6	6	6	6	6	6	6
22	6	6	6	6	6	6	6	6
23	6	6	6	6	6	6	6	6
24	6	6	6	6	6	6	6	6
25	6	6	6	6	6	9	9	9
26	8	8	8	8	8	8	8	8
27	8	8	8	8	8	8	8	8
28	8	8	8	8	8	8	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	8	6	6	8	4

NAVRONGO 2011

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	4	4	4	4	4	4	4	4
2	4	4	4	3	4	4	4	4
3	4	4	4	4	4	4	4	4
4	4	4	4	4	4	4	4	4
5	4	4	4	4	8	8	8	8
6	8	8	8	8	8	8	8	8
7	8	8	8	8	8	6	6	6
8	6	6	6	6	6	6	6	6
9	6	6	6	4	4	4	4	4
10	4	4	7	0.3	0.3	0.3	0.3	0.3
11	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
12	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
13	0.4	0.4	0.4	2	8	8	8	8
14	8	8	8	8	8	8	8	8
15	8	8	8	8	8	8	8	8
16	8	8	8	8	8	8	7	7
17	8	7	7	0.4	0.7	2	2	2
18	2	2	2	0.4	0.4	0.4	0.4	0.4
19	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
20	0.4	0.4	0.4	0.4	4	4	4	4
21	0.4	0.4	4	4	4	4	4	4
22	0.4	0.4	4	4	7	7	7	7
23	7	7	7	7	7	7	7	7
24	7	7	7	7	7	8	8	8
25	8	8	8	8	8	8	8	8
26	8	8	8	8	8	8	8	8
27	8	8	8	6	6	6	6	6
28	6	6	6	6	8	8	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	8	8	8	8	8

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	8	8	8	8	8
2	8	8	8	8	8	8	8	8
3	8	8	8	8	8	8	8	8
4	8	8	8	1	3	3	3	3
5	3	3	3	6	6	6	6	6
6	6	6	6	6	6	6	6	6
7	6	6	6	6	6	6	6	6
8	6	6	6	6	6	8	8	8
9	8	8	8	8	8	8	8	8
10	8	8	8	8	8	8	8	8
11	8	8	8	8	8	8	8	8
12	8	8	8	8	8	8	8	8
13	8	8	8	8	8	8	8	8
14	8	8	8	8	8	8	8	8
15	8	8	8	8	8	8	8	8
16	8	8	8	8	8	8	8	8
17	8	8	8	8	8	8	8	8
18	8	8	8	8	12	12	12	12
19	12	12	12	12	12	12	12	12
20	12	12	12	12	12	12	12	12
21	12	12	12	12	12	12	12	12
22	12	12	12	9	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	12	9	12	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	12	12	12	12
27	12	12	12	12	12	12	12	12
28	12	12	12	12	12	12	12	12
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	12	12
2	12	12	12	12	12	12	12	12
3	12	12	12	12	12	12	12	12
4	12	12	12	12	12	12	12	12
5	12	12	12	12	12	12	12	12
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	12	14	12	12	14	14	14	14
11	14	14	14	14	14	14	14	14
12	14	14	14	14	14	14	14	14
13	14	12	14	14	14	14	14	12
14	12	12	12	12	12	12	10	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	12	12	12	12	12
18	12	12	12	14	14	14	14	14
19	14	14	14	14	14	14	14	14
20	14	14	14	14	14	14	14	14
21	14	14	14	14	14	14	14	14
22	14	14	14	14	16	16	16	16
23	16	16	14	16	16	16	16	16
24	16	16	16	16	16	16	16	16
25	16	16	16	16	16	16	16	16
26	16	16	16	16	16	16	16	16
27	16	16	16	16	16	16	16	16
28	16	16	16	16	16	16	16	16
29	16	16	16	16	16	16	16	16
30	16	16	16	8	8	8	8	8
31	8	8	8	8	8	8	8	8

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	8	8	8	8	8
2	8	8	8	9	9	9	9	9
3	9	9	9	9	9	9	9	9
4	12	9	9	9	9	9	11	9
5	12	12	12	12	12	12	12	12
6	12	12	12	12	12	12	12	12
7	12	12	12	8	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	12	12	12	12	12	12	12	12
11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	12	12	12	12	12	12
15	12	12	12	12	12	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	12	12	12	12	12
18	12	12	12	12	12	12	12	12
19	12	12	12	14	14	14	14	12
20	9	12	12	12	12	12	12	12
21	12	12	12	16	16	16	12	12
22	12	12	12	12	12	12	12	12
23	12	12	12	12	12	12	8	8
24	8	8	8	12	12	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	12	12	12	12
27	12	12	12	14	14	14	14	14
28	12	12	12	12	12	12	12	12
29	12	12	12	12	12	12	12	12
30	12	12	12	12	12	12	12	12
31								

MAY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	12	12
2	12	9	9	12	12	12	12	12
3	12	12	12	16	16	16	16	16
4	16	16	16	16	16	16	16	14
5	14	14	14	14	14	14	14	14
6	14	14	14	14	14	14	14	9
7	11	11	11	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	12	12	12	12	12	14	14	14
11	12	12	9	12	12	12	12	12
12	12	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	12	12	12	12	12	12
15	12	12	14	14	14	14	14	14
16	14	14	14	14	14	14	14	14
17	14	14	14	14	14	14	14	14
18	14	12	12	12	12	12	12	12
19	12	12	12	12	12	12	12	12
20	12	12	12	14	14	14	14	14
21	14	14	14	14	14	14	14	14
22	14	14	14	14	14	14	9	12
23	12	12	12	8	12	12	12	12
24	12	12	12	12	16	16	16	16
25	16	16	16	16	16	16	16	14
26	14	14	14	14	14	14	14	9
27	14	14	14	14	14	14	14	14
28	14	14	14	14	14	14	14	14
29	14	14	14	14	14	14	14	14
30	14	14	14	16	16	16	16	16
31	16	16	16	16	16	16	14	10

JUNE

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	14	14	14	14	14	14
2	16	14	14	14	14	16	16	16
3	16	16	16	16	16	16	16	16
4	16	16	16	12	14	16	16	14
5	14	14	14	14	14	14	14	14
6	14	14	14	14	14	14	14	14
7	14	14	14	14	14	14	14	14
8	14	14	14	10	14	14	14	14
9	14	14	14	14	14	14	14	14
10	14	14	14	14	14	14	14	14
11	14	14	14	14	14	14	14	14
12	14	14	14	14	14	14	14	14
13	14	14	14	14	14	14	14	10
14	14	14	14	14	14	16	16	16
15	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	16
17	16	16	16	16	16	16	16	16
18	16	16	16	16	16	16	16	16
19	16	16	16	16	16	16	16	16
20	16	16	16	16	10	14	14	14
21	14	14	14	14	14	14	14	14
22	14	14	14	14	14	16	16	16
23	6	14	14	16	16	16	16	16
24	16	16	16	16	16	16	16	16
25	9	14	12	12	12	12	12	12
26	12	14	12	12	12	16	16	16
27	16	16	16	16	16	16	16	14
28	14	14	14	14	14	16	16	14
29	14	14	14	14	14	14	6	12
30	12	12	12	16	16	16	16	16
31								

JULY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	14	18	18	18	18	18
2	18	18	18	18	18	18	18	18
3	18	18	18	18	18	18	18	18
4	18	18	18	18	18	18	18	18
5	18	18	18	18	18	18	18	16
6	14	8	14	14	14	14	14	14
7	14	14	14	14	14	14	14	14
8	14	14	14	14	14	16	16	16
9	16	16	16	16	16	9	9	12
10	12	12	12	14	14	14	14	14
11	14	14	14	14	14	14	14	14
12	14	14	14	14	14	16	16	16
13	16	16	16	16	16	14	14	14
14	14	14	14	14	14	12	12	12
15	12	12	12	14	14	12	12	12
16	12	12	12	12	12	16	16	16
17	16	16	16	16	16	16	16	16
18	16	16	16	8	12	14	14	14
19	14	14	14	14	14	14	14	14
20	14	14	14	14	14	14	14	14
21	14	14	14	14	14	14	14	14
22	14	14	14	14	14	14	14	14
23	14	14	14	16	16	16	16	16
24	16	16	16	16	12	16	16	16
25	16	16	16	16	16	16	16	14
26	14	14	14	14	14	16	16	16
27	16	16	16	16	16	16	16	16
28	16	16	16	16	16	16	16	12
29	14	14	14	14	14	14	14	10
30	10	10	11	12	12	12	12	14
31	14	14	14	14	14	16	16	16

AUGUST

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	16	10	11	12
2	12	12	12	12	12	12	12	12
3	12	12	12	12	12	12	12	12
4	12	12	12	12	12	12	12	12
5	12	12	12	12	12	16	16	16
6	16	16	16	16	16	10	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	0.6	12	12	14	14	14
10	14	14	14	14	14	14	14	14
11	14	14	14	14	14	14	14	14
12	14	14	14	14	14	16	16	16
13	16	16	16	4	12	12	12	12
14	12	12	12	16	16	16	16	16
15	16	16	6	14	14	14	14	11
16	11	11	11	14	14	14	12	12
17	12	12	12	12	12	14	14	14
18	14	10	9	14	14	14	9	12
19	12	12	12	12	14	14	14	14
20	14	14	14	14	14	12	14	14
21	14	14	6	12	12	12	12	12
22	12	12	10	8	8	12	12	12
23	12	12	12	12	12	14	14	9
24	12	12	9	12	12	12	12	12
25	14	14	14	14	14	14	10	8
26	12	12	12	12	12	12	12	12
27	12	12	12	14	14	14	14	14
28	14	8	12	12	12	12	12	12
29	12	12	12	12	12	14	14	14
30	14	14	14	14	14	14	14	6
31	6	12	12	12	14	14	14	12

SEPTEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	14	14	14	14	14
2	14	14	14	14	14	14	10	12
3	12	12	12	12	12	12	12	12
4	12	12	12	12	12	12	12	12
5	12	12	12	12	12	12	12	12
6	12	12	12	12	12	14	14	14
7	12	12	12	16	16	16	16	16
8	16	16	16	16	16	12	12	12
9	12	12	12	12	14	14	14	14
10	14	14	14	8	12	14	14	14
11	14	14	14	14	14	14	14	14
12	14	14	14	14	14	14	14	14
13	14	9	12	14	14	12	12	12
14	12	12	12	12	12	14	14	14
15	14	14	14	14	14	14	14	14
16	12	12	12	12	12	12	12	12
17	10	6	12	14	14	14	14	14
18	14	14	14	14	14	14	14	14
19	14	14	14	14	14	12	12	12
20	12	12	12	12	12	12	12	12
21	12	12	12	14	14	14	14	14
22	14	14	10	12	12	12	12	12
23	12	12	12	12	12	12	12	12
24	12	12	12	12	10	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	16	16	16	16
27	16	16	16	16	16	16	16	16
28	16	16	16	16	16	16	16	16
29	16	16	16	16	16	16	16	16
30	12	12	12	12	12	12	10	10
31								

OCTOBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	12	12
2	12	12	12	14	14	14	14	14
3	14	14	14	14	14	14	14	14
4	14	14	14	16	16	16	16	16
5	16	16	16	16	16	16	16	14
6	14	14	14	14	14	12	12	12
7	10	12	12	14	14	14	14	14
8	14	14	14	14	14	14	14	14
9	14	14	14	14	14	16	14	14
10	14	10	14	14	14	14	14	14
11	14	14	14	14	14	16	16	16
12	16	16	16	16	16	16	16	14
13	14	14	14	14	14	14	14	14
14	14	14	14	14	14	16	16	16
15	16	16	16	16	16	16	16	16
16	16	16	16	16	16	8	8	8
17	8	8	8	8	8	8	8	8
18	8	8	8	8	8	8	8	8
19	8	8	8	9	12	12	12	12
20	12	12	12	8	8	8	8	8
21	8	8	8	8	8	8	8	8
22	8	8	8	9	9	9	8	8
23	8	8	8	8	8	8	8	8
24	8	8	9	9	9	9	9	9
25	9	9	9	9	9	9	9	9
26	9	8	12	12	12	12	8	8
27	8	8	8	9	9	9	7	7
28	7	12	12	14	14	14	14	14
29	14	14	14	9	9	9	8	8
30	8	8	8	8	8	8	8	8
31	8	12	12	8	9	9	9	9

NOVEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	9	9	9	9	9	9	8	8
2	8	8	5	8	8	8	8	8
3	8	8	8	8	8	8	8	8
4	8	8	8	8	8	8	8	8
5	8	8	8	8	8	8	8	8
6	8	8	6	8	8	8	8	8
7	8	8	8	8	8	8	8	8
8	8	8	8	8	8	8	8	8
9	8	8	8	6	8	8	8	8
10	8	8	8	6	6	6	6	6
11	6	6	6	6	6	6	6	6
12	6	6	6	6	6	6	6	6
13	6	6	6	6	6	6	6	6
14	6	6	6	6	6	6	6	6
15	6	6	6	6	6	6	6	6
16	6	6	6	6	6	6	6	6
17	6	6	6	6	6	6	6	6
18	6	6	6	6	6	7	7	7
19	7	7	7	7	7	7	7	7
20	7	7	6	6	6	6	6	6
21	6	6	6	6	6	6	6	6
22	6	6	6	6	7	7	7	7
23	7	7	7	6	6	6	6	6
24	6	6	6	6	6	6	6	6
25	6	6	6	6	6	6	6	6
26	6	6	6	6	6	6	6	6
27	6	6	6	6	6	6	6	6
28	6	6	6	6	6	6	6	6
29	6	6	6	6	6	6	6	6
30	6	6	6	6	4	4	4	4
31								

DECEMBER

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	4	4	4	4	4	4	4	4
2	4	4	4	6	6	6	6	6
3	6	6	6	6	6	6	6	6
4	6	6	6	6	6	6	6	6
5	6	6	6	6	6	6	6	6
6	6	6	5	5	5	5	5	5
7	5	5	4	4	4	4	4	4
8	4	4	4	4	4	4	4	4
9	4	4	4	4	4	4	4	4
10	4	4	4	4	4	4	4	4
11	4	4	4	1	1	1	1	1
12	1	1	1	0.8	0.8	0.8	0.8	0.8
13	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
14	0.8	0.8	0.8	0.8	1	1	1	1
15	1	1	1	5	5	5	5	5
16	5	5	5	5	5	5	5	5
17	5	5	5	5	5	5	5	5
18	5	5	5	5	5	5	5	5
19	5	5	5	5	5	5	5	5
20	5	5	5	6	8	8	8	8
21	8	8	8	8	8	8	8	8
22	8	8	8	8	8	8	8	8
23	8	8	8	8	8	8	8	8
24	8	8	8	8	8	8	8	8
25	8	8	8	8	8	8	8	8
26	8	8	8	8	8	8	8	8
27	8	8	8	8	8	8	8	8
28	8	8	8	8	8	8	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	8	8	8	8	8

WA 2010

JANUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	9	9	9	9	8
2	8	8	8	8	8	8	8	8
3	8	8	8	8	8	8	8	8
4	8	8	8	8	8	8	8	8
5	8	8	8	8	8	9	9	9
6	8	8	8	8	8	8	8	8
7	8	8	8	8	8	9	9	9
8	9	9	9	9	9	9	9	9
9	9	9	9	9	9	9	9	9
10	9	9	9	9	9	9	9	9
11	9	9	9	9	9	9	9	8
12	8	8	8	8	8	8	9	9
13	9	9	9	6	6	6	6	6
14	6	6	6	6	6	6	6	6
15	6	6	6	6	6	7	7	7
16	7	7	7	8	8	8	8	7
17	7	7	7	8	8	9	9	9
18	7	9	9	9	9	9	9	9
19	7	9	9	8	9	9	9	9
20	7	9	9	9	9	9	9	9
21	7	9	9	9	9	9	9	8
22	8	8	8	7	7	7	7	7
23	7	7	7	8	6	7	7	7
24	9	9	9	9	9	9	9	9
25	9	9	9	9	9	9	9	9
26	9	9	9	8	8	8	8	8
27	8	8	8	8	8	8	8	8
28	8	8	8	8	8	9	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	8	8	8	8	8

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	8	8	8	8	8
2	8	8	8	8	8	8	8	8
3	8	8	8	8	8	8	8	8
4	8	8	8	8	8	8	8	8
5	8	8	8	8	8	8	8	8
6	8	8	8	6	3	1.5	1.5	1.5
7	1.5	1.5	1.5	0.8	0.8	0.5	0.5	0.5
8	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.7
9	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
10	0.8	0.8	0.8	0.8	1.5	3	3	3
11	3	3	3	3	3	3	3	3
12	3	3	3	5	6	6	6	6
13	6	6	6	6	6	6	6	6
14	6	6	6	6	6	6	6	6
15	6	6	6	6	6	6	6	6
16	6	6	6	6	6	6	6	6
17	6	6	6	6	6	7	7	7
18	7	7	7	7	7	7	7	7
19	7	7	7	7	7	7	7	7
20	7	7	7	8	12	12	12	12
21	12	12	12	12	15	15	15	15
22	15	15	15	15	15	15	15	15
23	15	15	15	15	10	10	10	10
24	10	10	10	10	10	10	10	10
25	10	10	10	10	10	10	10	10
26	10	10	10	10	10	10	10	10
27	10	10	10	8	8	8	8	8
28	8	8	8	8	8	8	8	8
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	8	8	8	8	8	8	8	8
2	8	8	8	8	8	8	8	8
3	8	8	8	8	8	8	8	8
4	8	8	8	8	8	8	8	10
5	10	10	10	10	10	10	10	10
6	10	10	10	10	10	12	12	10
7	10	10	10	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	13	13	13	13
10	13	13	13	8	6	3	3	3
11	3	3	3	8	8	8	8	8
12	8	8	8	8	8	8	8	8
13	8	8	8	8	8	8	8	8
14	8	8	8	8	12	12	12	10
15	10	10	10	10	10	10	12	12
16	12	12	12	8	8	8	8	8
17	8	8	8	8	8	6	6	6
18	6	6	6	6	3	3	2	2
19	2	2	2	2	2	2	2	2
20	2	2	2	0.8	0.8	0.8	0.8	0.8
21	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
22	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
23	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
24	0.8	0.8	0.8	0.8	2	2	2	2
25	2	2	2	2	2	4	4	4
26	4	4	4	4	5	6	6	6
27	6	6	6	6	6	6	6	6
28	6	6	6	6	6	6	6	6
29	6	6	6	6	6	6	6	6
30	10	6	10	10	1.2	1.2	1.2	1.2
31	1.2	1.2	1.2	6	6	6	6	6

APRIL

Day of Month	Visibility Measurement(Km) taken on : Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	6	6	6	6	6	6	6	6
2	6	6	6	6	8	8	8	6
3	8	8	8	8	10	10	10	8
4	10	10	10	10	10	10	10	10
5	10	10	10	10	10	12	12	10
6	12	12	12	12	12	12	12	12
7	12	12	12	12	12	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	12	12	12	12	12	12	12	12
11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	14	14	14	14	14	12
15	14	14	14	14	14	14	14	14
16	14	14	14	14	14	14	14	14
17	14	14	14	14	14	14	14	14
18	14	14	14	14	14	14	14	14
19	12	12	12	12	15	15	15	12
20	15	15	15	15	15	15	15	15
21	15	15	15	15	15	15	15	15
22	15	15	15	15	15	15	15	15
23	15	15	15	15	15	15	15	15
24	15	15	15	15	15	15	15	15
25	15	15	15	15	15	15	15	15
26	15	15	15	15	15	15	15	15
27	15	15	15	15	15	15	15	15
28	15	15	15	15	15	15	15	15
29	15	15	15	15	15	15	15	15
30	15	15	15	15	15	15	15	15
31								

MAY								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	15	15	15	15	15	15	8	15
2	15	15	9	15	15	16	16	16
3	16	16	16	16	16	16	16	16
4	16	16	12	14	14	14	14	14
5	14	14	14	16	16	16	16	16
6	16	16	16	16	16	16	16	16
7	16	16	16	16	16	16	16	16
8	16	16	16	16	16	16	16	16
9	16	8	14	14	16	16	16	16
10	16	16	16	16	16	16	16	16
11	16	16	16	16	10	16	16	16
12	16	16	16	16	16	16	16	16
13	16	16	16	16	12	14	14	14
14	14	14	14	14	14	16	16	16
15	16	16	16	16	16	16	16	16
16	16	15	15	15	15	15	15	15
17	15	15	15	15	15	16	16	16
18	16	16	16	16	16	16	16	16
19	16	16	16	16	16	16	16	16
20	16	16	16	16	16	16	16	16
21	16	16	16	16	16	16	16	16
22	16	16	16	16	16	16	16	16
23	16	16	16	16	16	16	16	16
24	10	16	14	14	14	16	16	16
25	16	16	16	15	16	16	16	16
26	16	16	16	16	16	16	16	16
27	16	16	16	16	16	16	16	16
28	16	16	16	16	16	16	16	16
29	10	12	14	14	14	16	16	16
30	16	16	16	16	16	9	12	14
31	14	14	14	14	14	14	14	14

JUNE								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	14	14	14	16	16	16	16	14
2	14	14	14	16	16	16	16	16
3	16	16	16	16	16	16	16	16
4	16	16	16	14	18	18	18	16
5	16	16	16	16	16	18	18	18
6	16	16	16	18	18	18	18	16
7	16	16	16	18	18	18	18	14
8	14	14	14	14	14	16	16	16
9	16	16	16	16	16	16	16	16
10	16	16	16	16	16	18	13	12
11	16	16	16	18	18	18	18	16
12	16	16	16	16	18	18	10	14
13	14	14	14	14	14	16	16	16
14	16	16	16	18	18	18	18	16
15	16	16	16	18	18	18	18	18
16	16	16	16	16	16	16	14	14
17	14	14	14	16	16	16	16	16
18	14	12	14	14	14	16	16	16
19	16	16	16	16	16	16	16	16
20	16	16	16	16	16	18	18	18
21	18	12	12	16	18	16	16	12
22	14	14	14	14	16	16	12	12
23	12	12	14	14	14	16	16	16
24	16	16	16	16	16	10	12	12
25	12	12	12	12	16	18	18	18
26	18	18	18	18	18	18	18	16
27	16	16	16	18	18	18	18	16
28	16	16	16	16	16	10	10	12
29	12	12	12	12	15	15	15	15
30	12	15	15	18	18	18	18	18
31								

JULY								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	18	18	18	18	18	18	18	18
2	12	12	15	16	16	16	16	16
3	16	16	16	16	16	16	10	10
4	14	14	14	16	16	10	12	12
5	12	12	12	12	12	18	18	18
6	18	18	14	16	16	16	16	16
7	16	16	16	16	16	16	16	16
8	16	16	16	10	10	16	16	12
9	12	12	12	16	16	18	18	16
10	16	16	16	16	16	20	20	16
11	16	16	16	18	18	18	18	14
12	16	16	16	16	16	16	16	14
13	16	16	16	16	16	18	18	18
14	18	18	18	18	18	18	18	16
15	16	8	10	12	12	18	18	18
16	16	16	16	18	18	18	18	16
17	16	16	16	16	16	16	16	16
18	16	16	16	16	16	18	18	18
19	18	18	18	18	18	12	12	14
20	14	14	14	14	14	18	18	18
21	18	18	18	18	18	18	18	16
22	16	16	12	14	14	16	16	16
23	16	16	16	16	16	16	16	16
24	16	16	16	18	18	18	18	16
25	16	16	16	16	16	18	18	18
26	18	18	18	18	18	18	18	16
27	16	16	16	16	16	18	18	12
28	14	14	14	14	14	16	16	16
29	16	16	16	16	16	16	16	16
30	16	16	16	16	16	18	18	16
31	16	16	16	18	18	18	18	12

AUGUST								
Day of	**Visibility Measurement(Km) taken on : Hour of Day (GMT)**							
Month	**0:00**	**3:00**	**6:00**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**
1	16	16	16	16	16	18	18	16
2	16	16	16	18	18	18	18	16
3	16	16	16	16	10	16	16	16
4	16	16	12	12	14	16	16	16
5	16	14	14	16	18	18	18	16
6	16	16	16	16	16	18	18	18
7	18	18	10	10	18	14	16	16
8	16	16	14	14	16	16	16	16
9	16	16	16	16	16	18	18	16
10	16	16	16	16	16	16	16	16
11	16	16	16	16	16	18	18	16
12	16	16	16	10	16	16	16	16
13	16	16	16	16	16	16	16	16
14	16	16	16	16	16	16	14	14
15	10	10	14	16	16	16	16	16
16	16	16	16	16	16	18	18	18
17	16	16	16	18	18	18	18	16
18	16	16	15	18	18	18	18	10
19	14	14	14	16	18	18	18	16
20	16	16	16	16	18	18	18	16
21	16	16	16	18	18	18	10	10
22	15	15	15	18	18	18	18	16
23	16	16	16	18	18	18	18	16
24	16	16	16	18	18	18	18	16
25	16	16	16	16	18	18	15	15
26	15	15	15	18	18	18	18	18
27	16	16	16	18	18	18	18	16
28	16	16	16	18	18	28	28	28
29	16	12	14	18	18	18	18	16
30	16	16	16	18	18	18	18	16
31	16	16	16	16	16	18	18	18

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	12	16	18	18	18	16
2	16	16	16	12	12	16	16	16
3	16	16	16	16	18	18	18	16
4	16	16	16	18	18	18	18	16
5	16	16	16	16	16	12	10	12
6	12	12	12	12	12	14	14	14
7	14	14	14	16	16	18	18	14
8	14	14	12	16	18	18	12	11
9	12	12	14	14	14	16	16	16
10	16	16	16	16	18	18	12	15
11	15	15	0.6	12	12	16	16	16
12	16	16	16	10	14	14	14	14
13	14	14	14	16	18	18	18	16
14	16	16	16	18	18	18	18	18
15	18	18	16	16	16	12	16	16
16	16	16	16	16	16	16	16	16
17	16	16	16	16	10	14	14	14
18	14	12	12	16	18	18	10	14
19	14	14	14	12	16	12	16	14
20	14	14	14	18	18	18	12	14
21	14	14	14	14	14	14	14	14
22	14	14	14	16	12	14	16	14
23	16	16	16	18	18	18	18	16
24	16	16	16	18	18	18	18	16
25	15	15	15	18	18	18	18	1
26	16	16	16	16	16	16	16	14
27	14	14	14	12	12	16	16	14
28	14	14	14	16	18	18	18	16
29	16	16	16	16	18	18	14	10
30	10	12	14	16	18	18	18	16
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	16	16	10	14	14
2	14	14	14	16	16	18	18	14
3	12	14	14	16	18	18	18	16
4	12	14	14	14	18	18	18	16
5	16	16	16	18	18	18	18	16
6	16	12	14	16	16	16	16	14
7	10	14	14	14	14	16	16	16
8	12	8	10	14	15	18	18	16
9	16	16	16	16	18	18	18	18
10	12	12	12	18	18	18	18	16
11	16	16	16	16	16	16	16	16
12	16	16	16	16	16	18	18	16
13	16	16	16	18	18	18	18	16
14	16	16	16	16	16	16	16	16
15	18	18	18	18	18	18	18	14
16	14	14	14	14	14	14	14	14
17	12	12	10	14	14	18	18	14
18	14	14	14	18	18	18	18	16
19	16	16	16	16	16	18	18	18
20	18	18	18	18	18	12	12	14
21	14	14	16	16	16	16	14	10
22	14	14	14	16	16	18	18	14
23	14	14	14	18	18	18	18	16
24	16	16	16	16	16	18	18	18
25	18	18	18	18	18	18	18	14
26	14	14	14	14	14	16	16	16
27	16	16	12	14	14	18	18	14
28	14	14	14	16	16	16	16	14
29	14	14	14	14	16	18	18	18
30	18	18	18	18	18	18	18	14
31	16	16	16	16	16	16	12	14

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	14	14	14	16	16	16
2	14	14	14	14	14	16	16	14
3	14	14	14	14	18	18	18	18
4	18	18	18	18	18	18	18	14
5	14	14	14	14	14	14	14	14
6	14	14	14	14	14	16	16	14
7	14	14	14	16	16	16	12	14
8	14	14	14	14	14	16	16	16
9	16	16	16	18	18	18	18	16
10	16	16	16	16	16	16	16	16
11	16	16	16	16	16	14	14	14
12	14	14	14	14	14	15	15	14
13	14	14	14	14	14	16	16	16
14	16	16	16	18	18	18	18	16
15	16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16	14
17	14	14	14	14	14	14	14	14
18	14	14	14	14	14	18	18	18
19	18	18	18	18	20	20	18	16
20	16	16	16	16	16	16	16	16
21	16	16	16	16	16	18	18	18
22	16	16	12	16	16	16	16	14
23	14	14	14	14	14	14	14	14
24	14	14	14	14	14	14	14	14
25	14	14	14	14	14	14	14	14
26	14	14	12	10	10	10	10	10
27	10	10	10	10	10	10	10	10
28	10	10	10	12	12	12	12	12
29	12	12	12	12	12	14	12	12
30	12	12	12	12	12	12	12	12
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	12	12	12	12	12
2	12	12	12	12	12	12	12	10
3	10	10	10	10	10	10	10	10
4	10	10	10	12	12	12	12	10
5	10	10	10	10	12	10	10	10
6	10	10	10	10	10	10	10	10
7	10	10	10	10	10	12	12	12
8	12	12	12	12	12	12	12	12
9	12	12	12	12	12	12	12	12
10	12	12	12	10	12	12	12	12
11	12	12	12	10	12	12	12	12
12	12	12	12	12	12	12	12	12
13	12	12	12	12	12	12	12	12
14	12	12	12	12	12	12	12	10
15	10	10	10	10	10	12	12	12
16	12	12	12	12	12	12	12	12
17	12	12	12	12	12	12	12	12
18	12	12	12	12	10	8	8	8
19	8	8	8	8	8	8	8	8
20	8	8	8	8	8	8	8	8
21	8	8	8	8	8	8	8	8
22	8	8	8	8	8	8	8	8
23	8	8	8	8	8	8	8	8
24	8	8	8	8	8	8	8	8
25	8	8	8	8	8	8	8	8
26	8	8	8	8	8	8	8	8
27	8	8	8	8	8	8	8	8
28	8	8	8	8	8	8	8	8
29	8	8	8	8	8	8	8	8
30	8	8	8	8	8	8	8	8
31	8	8	8	8	8	8	8	8

WA 2011

JANUARY

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	9	9	9	9	9	9	9	9
2	9	9	9	9	9	9	9	9
3	9	9	9	8	8	8	8	8
4	8	8	8	8	8	9	9	9
5	9	9	9	8	8	8	8	8
6	8	8	8	8	9	9	9	8
7	8	8	8	8	8	8	8	8
8	8	8	8	8	8	8	8	8
9	8	8	8	8	6	6	6	6
10	6	6	6	1.5	1	1	1	1
11	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1
13	1	1	1	2	2	2	2	2
14	2	2	2	2	2	2	2	2
15	2	2	2	2	2	2	2	2
16	2	2	2	1.2	2	2	2	2
17	2	2	2	1.2	1.2	1.2	1.2	1.2
18	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
19	1.2	1.2	1.2	1.2	1.2	1.2	1.5	1.5
20	1.5	1.5	1.5	2	2	2	2.5	2
21	2	2	2	2	2.5	2.5	2.5	2.5
22	2.5	2.5	2.5	2.5	2.5	3	3	2.5
23	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
24	2.5	2.5	2.5	2	2.5	2.5	2.5	2.5
25	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
26	2.5	2.5	2.5	2.5	3	3	3	3
27	3	3	3	3	3	3.5	3.5	3.5
28	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3
29	3	3	3	3.5	3.5	3.5	3.5	3.5
30	3.5	3.5	3.5	3	3.5	3.5	3.5	3
31	3	3	3	3	3	3.5	5	5

FEBRUARY

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	5	5	5	4.5	5	5	5	4.5
2	4.5	4.5	4.5	5	5	5	5	5
3	10	10	10	13	13	13	13	12
4	12	12	12	10	10	10	10	10
5	10	10	10	10	10	10	10	10
6	10	10	10	10	10	12	12	10
7	10	10	10	10	10	10	10	10
8	10	10	10	10	10	12	12	10
9	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10
11	10	10	10	10	10	10	10	10
12	10	10	10	10	10	10	10	10
13	10	10	10	10	10	10	10	10
14	10	10	10	10	10	10	10	10
15	10	10	10	10	10	10	10	10
16	10	10	10	10	10	10	10	10
17	10	10	10	10	10	10	10	10
18	10	10	10	10	10	10	10	10
19	10	10	10	10	10	10	10	10
20	10	10	10	10	10	12	10	10
21	10	10	10	10	10	10	12	10
22	10	10	10	10	10	10	10	10
23	10	10	10	10	10	10	10	10
24	10	10	10	10	10	10	10	10
25	10	10	10	10	10	10	10	10
26	10	10	10	10	10	10	10	10
27	10	10	10	10	10	10	10	10
28	10	10	10	10	10	10	10	10
29								
30								
31								

MARCH

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	10	10	10	12	12	12	12	10
2	10	10	10	10	10	10	10	10
3	10	10	10	10	10	10	10	10
4	10	10	10	10	13	15	15	15
5	15	15	15	15	15	15	15	15
6	15	15	15	15	15	15	15	15
7	15	15	15	15	15	15	15	15
8	12	15	15	15	15	18	18	16
9	16	16	16	18	18	18	18	16
10	15	15	15	15	15	15	15	15
11	15	15	15	15	15	15	15	15
12	15	15	15	15	15	15	15	15
13	15	15	15	18	18	18	18	15
14	15	15	15	15	15	15	15	15
15	10	18	18	18	18	18	18	16
16	16	16	16	18	18	18	18	16
17	16	16	16	18	18	18	18	16
18	16	16	16	16	16	16	16	15
19	15	15	15	16	16	18	18	16
20	16	16	16	16	18	18	18	16
21	16	16	16	18	18	18	18	16
22	16	16	16	16	18	18	18	18
23	18	18	18	18	18	18	18	16
24	16	16	16	18	18	18	18	16
25	16	16	16	18	18	18	18	16
26	16	16	16	18	18	18	18	16
27	16	16	16	18	18	18	18	15
28	16	16	16	18	18	20	20	18
29	18	18	18	20	20	20	20	16
30	16	16	16	18	18	18	18	16
31	16	16	16	18	18	18	18	16

APRIL

Day of Month	Visibility Measurement(Km) taken on: Hour of Day (GMT) 0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	18	18	20	20	16
2	18	18	18	20	20	20	20	18
3	18	18	18	18	18	18	18	18
4	16	16	16	18	18	18	18	16
5	14	12	16	16	18	18	18	14
6	16	16	16	18	18	18	18	14
7	16	16	16	18	18	18	18	16
8	16	16	16	18	18	18	18	16
9	16	16	16	18	18	20	20	16
10	18	18	18	20	20	20	20	18
11	16	16	16	16	18	20	20	16
12	16	16	16	18	18	18	18	16
13	16	16	16	16	16	16	16	16
14	16	16	16	18	18	18	18	16
15	16	16	16	16	18	18	18	16
16	16	16	16	16	18	20	20	16
17	18	18	18	20	20	20	20	16
18	16	16	16	16	16	18	18	16
19	16	16	16	18	18	18	18	16
20	16	10	16	18	18	18	18	16
21	16	16	16	18	18	18	18	16
22	16	16	16	16	18	18	18	16
23	16	16	16	18	18	18	18	16
24	16	16	16	18	18	18	18	16
25	16	16	16	18	18	18	18	16
26	16	16	16	18	18	18	18	16
27	16	16	16	18	18	18	18	16
28	16	16	16	18	18	18	18	16
29	16	16	16	18	18	18	18	16
30	16	16	16	18	18	20	18	16
31								

MAY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	18	18	18	18	18	18	18	16
2	16	16	16	18	18	20	20	16
3	16	16	16	18	18	18	18	16
4	16	16	16	18	18	18	18	16
5	16	16	16	18	18	18	18	16
6	16	16	16	18	18	18	18	12
7	12	16	16	16	18	18	18	16
8	16	16	16	18	10	12	14	14
9	14	14	14	18	18	18	18	16
10	16	16	16	18	18	18	18	16
11	16	16	16	16	16	16	16	16
12	10	16	16	10	16	16	16	16
13	16	16	16	18	18	18	18	16
14	16	16	16	18	18	18	18	16
15	16	16	16	18	18	18	18	16
16	16	16	16	18	16	16	16	16
17	16	16	16	18	18	18	18	16
18	16	16	16	18	18	18	18	16
19	16	16	16	18	18	16	18	16
20	16	16	16	16	16	18	16	0.4
21	16	16	16	16	16	18	18	16
22	16	16	16	18	18	18	14	16
23	16	16	16	16	10	12	12	14
24	16	14	14	16	16	16	16	16
25	16	16	16	16	16	18	18	16
26	16	16	16	18	18	18	18	16
27	12	16	16	16	16	16	16	14
28	14	14	14	18	18	18	18	16
29	12	10	12	14	16	18	18	14
30	14	14	14	18	18	18	18	16
31	16	16	16	16	16	16	16	14

JUNE								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	14	14	14	14	16	16	16	14
2	14	14	14	16	16	18	18	18
3	16	16	16	18	18	18	18	18
4	18	18	18	18	18	18	18	16
5	16	16	12	14	14	14	14	14
6	14	14	14	16	18	18	18	16
7	16	16	16	18	18	18	13	16
8	16	16	16	18	18	18	13	16
9	16	16	16	18	18	18	13	16
10	16	16	16	18	18	18	13	18
11	18	18	18	18	18	18	13	16
12	16	16	16	16	16	18	13	16
13	16	16	16	18	18	18	13	15
14	15	15	15	16	16	16	12	12
15	12	12	14	16	16	16	16	16
16	16	16	16	18	18	18	18	16
17	16	16	16	18	18	18	18	10
18	15	15	15	16	18	18	18	16
19	16	16	16	16	16	16	16	10
20	16	16	14	16	16	10	16	16
21	16	16	16	16	16	18	18	18
22	18	18	18	18	18	18	18	18
23	18	18	18	18	18	18	18	16
24	16	16	16	14	16	16	16	16
25	14	12	14	16	16	16	16	16
26	16	16	16	16	16	18	18	16
27	16	16	16	18	18	18	18	16
28	16	16	16	18	18	18	18	16
29	16	16	16	16	18	18	18	16
30	16	16	16	16	16	16	16	16
31								

JULY								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	10	12	14	14	16	16	12
2	14	14	14	18	18	18	18	14
3	16	16	16	18	18	18	18	16
4	18	18	18	18	18	18	18	18
5	16	16	16	18	16	16	16	16
6	16	10	16	16	16	18	18	16
7	16	16	16	16	18	18	18	16
8	16	16	16	16	18	18	18	16
9	16	16	16	18	18	18	14	16
10	16	12	12	14	16	16	16	16
11	16	16	16	16	16	18	18	16
12	16	16	16	16	18	18	12	16
13	16	16	16	16	18	18	12	16
14	15	15	15	18	16	16	16	15
15	15	15	15	18	16	16	16	15
16	15	15	15	15	15	15	15	15
17	12	12	12	15	15	16	16	12
18	16	16	16	15	18	18	18	16
19	16	16	16	16	15	15	15	16
20	15	15	15	12	15	15	15	15
21	15	15	15	15	15	15	15	15
22	15	10	10	15	15	16	16	15
23	16	16	16	16	18	18	18	16
24	16	16	16	18	18	18	18	16
25	15	15	15	15	15	15	15	15
26	14	14	14	15	15	15	15	14
27	15	15	15	15	18	18	18	15
28	18	18	18	18	18	18	18	18
29	16	16	16	18	18	18	18	16
30	15	15	15	15	16	16	16	15
31	15	12	15	15	15	15	15	15

AUGUST								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	15	15	15	18	18	18	15	10
2	12	14	14	18	18	18	18	15
3	15	15	15	13	15	15	15	15
4	15	15	15	15	15	15	15	15
5	15	5	12	15	15	18	18	18
6	18	16	16	16	16	18	18	16
7	16	16	16	18	18	18	18	15
8	15	15	15	16	16	12	12	12
9	12	12	12	12	12	15	15	15
10	15	15	15	15	15	18	18	15
11	15	15	15	18	18	18	18	16
12	16	16	16	18	18	18	18	15
13	15	15	15	16	18	10	14	14
14	14	14	14	14	14	15	15	15
15	15	15	15	15	15	18	10	14
16	14	8	12	16	18	18	18	16
17	16	16	16	18	18	18	16	14
18	14	14	14	16	16	16	16	16
19	16	16	16	16	16	16	16	14
20	14	14	14	15	15	16	16	16
21	16	16	16	18	16	18	18	16
22	16	16	16	16	18	18	18	14
23	14	14	14	16	16	16	12	14
24	16	16	16	16	18	18	18	16
25	16	16	0.8	12	12	16	16	12
26	12	12	12	16	16	16	16	15
27	14	14	14	18	18	18	18	16
28	16	14	12	12	16	16	16	14
29	14	14	14	14	16	16	16	14
30	14	14	14	16	16	18	18	18
31	14	14	14	16	16	18	18	10

SEPTEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	14	16	18	18	18	18	15
2	15	15	15	18	18	18	18	12
3	16	16	16	18	18	18	18	15
4	16	16	16	16	16	16	16	16
5	14	14	14	16	16	18	18	16
6	16	16	16	18	18	18	18	15
7	15	15	15	18	18	18	18	14
8	14	14	14	14	18	18	18	16
9	16	16	16	16	16	18	18	18
10	16	16	16	16	16	18	18	16
11	16	16	16	18	18	18	18	15
12	15	15	15	18	18	18	18	14
13	14	14	14	18	18	18	10	12
14	14	14	14	18	18	18	18	18
15	14	14	14	16	16	18	14	15
16	15	15	15	18	18	18	18	15
17	15	15	12	12	10	14	14	14
18	14	14	14	16	18	18	18	16
19	16	16	16	18	18	18	18	18
20	16	16	16	18	18	16	12	14
21	14	14	14	18	18	18	18	15
22	15	15	15	16	16	18	18	16
23	16	16	4	15	18	18	18	16
24	16	16	16	18	18	12	16	16
25	16	16	16	16	18	18	18	12
26	14	14	14	18	18	18	18	16
27	16	12	15	16	16	18	18	16
28	16	16	16	18	18	18	18	16
29	16	16	16	18	18	18	18	18
30	16	16	16	16	16	18	18	10
31								

OCTOBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	12	12	12	16	18	18	18	16
2	16	16	16	18	18	18	18	16
3	16	16	16	18	18	18	18	16
4	16	16	16	18	18	18	18	18
5	16	16	12	12	16	16	16	16
6	16	16	16	16	18	18	18	18
7	12	12	12	18	18	18	18	18
8	16	16	16	18	18	18	18	16
9	16	16	16	18	18	18	18	16
10	16	16	14	12	16	18	18	18
11	18	18	10	18	18	18	18	16
12	16	16	16	18	18	18	18	16
13	16	16	16	18	18	18	18	16
14	16	16	16	18	18	18	18	16
15	16	16	16	16	16	18	16	16
16	16	16	16	18	18	18	18	16
17	16	16	16	18	18	18	18	16
18	16	16	16	18	18	18	18	16
19	12	16	16	16	16	16	16	16
20	16	16	16	16	16	18	18	18
21	18	18	18	18	18	18	18	16
22	16	16	16	16	18	18	18	16
23	16	16	16	18	18	18	18	16
24	16	16	16	16	16	16	16	16
25	16	16	16	16	16	18	18	18
26	18	18	18	18	18	18	18	16
27	16	16	16	18	18	18	18	16
28	16	16	16	18	18	18	18	16
29	16	16	16	16	18	18	18	18
30	16	16	16	16	16	18	18	18
31	18	18	18	18	18	18	18	16

NOVEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	16	16	16	18	18	16	18	16
2	16	16	16	18	18	18	18	16
3	16	16	16	16	16	16	16	16
4	16	16	16	16	16	18	18	18
5	18	18	18	18	18	18	18	16
6	16	16	16	16	16	18	18	16
7	16	16	16	18	18	18	18	16
8	16	16	16	16	16	16	16	16
9	16	16	16	16	16	18	18	18
10	18	18	18	18	18	18	18	16
11	16	16	16	18	18	18	18	16
12	16	16	16	16	16	16	16	15
13	15	15	15	15	15	15	15	15
14	15	15	15	15	15	18	18	18
15	18	18	18	16	18	18	18	16
16	16	16	16	18	16	16	16	16
17	16	16	16	16	16	16	16	15
18	15	15	15	8	8	9	9	9
19	9	9	9	8	8	9	9	9
20	9	9	8	8	9	9	9	8
21	8	8	8	9	9	9	9	9
22	8	8	8	8	9	10	10	10
23	10	10	10	10	10	10	10	10
24	10	10	10	10	10	12	12	12
25	12	12	12	12	12	12	12	12
26	12	12	12	12	12	12	12	10
27	10	10	10	10	12	12	12	12
28	12	12	12	12	12	12	12	12
29	12	12	12	8	8	9	9	9
30	9	9	9	9	9	9	9	9
31								

DECEMBER								
Day of	Visibility Measurement(Km) taken on : Hour of Day (GMT)							
Month	0:00	3:00	6:00	9:00	12:00	15:00	18:00	21:00
1	9	9	9	9	9	9	9	9
2	9	9	9	9	9	9	9	9
3	9	9	9	9	9	9	9	9
4	9	9	9	9	9	9	9	9
5	9	9	8	8	8	8	8	8
6	8	8	8	8	8	8	8	8
7	8	8	8	8	8	8	8	8
8	8	8	8	8	6	6	6	6
9	6	6	6	6	6	6	6	6
10	6	6	6	6	8	8	8	6
11	6	6	6	6	8	8	8	6
12	6	6	6	6	3	3	2.5	2.5
13	2.5	2.5	2.5	3	3	3	3	3
14	3	3	3	5	8	8	8	6
15	6	6	6	8	8	8	8	6
16	6	6	6	6	6	8	8	8
17	8	8	8	8	8	8	8	8
18	8	8	8	8	8	9	9	9
19	9	9	9	9	9	9	9	9
20	9	9	9	6	9	9	9	9
21	9	9	9	9	9	9	9	9
22	9	9	9	9	9	9	9	9
23	9	9	9	9	9	9	9	9
24	9	9	9	9	9	9	9	9
25	9	9	9	9	9	9	9	9
26	9	9	9	9	9	9	9	9
27	9	9	9	9	9	9	9	9
28	9	9	9	9	9	9	9	9
29	9	9	9	9	9	9	9	8
30	8	8	8	9	9	9	9	8
31	8	8	8	8	8	8	8	8

DECLARATION

I hereby declare that this submission is my own work towards MSc Telecommunication Engineering and that, to the best of my knowledge; it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where acknowledgement has been made in the text.

Prince Anokye (ID: PG5903011)

(Student Name & ID)

………………………………..

Signature

………………………………..

Date

Certified by:

Dr. James D. Gadze

(Supervisor)

………………………………………

Signature

………………………………………

Date

Certified by:

Prof. Philip Yaw Okyere

(Head of Department)

……………………………..

Signature

..………………………………

Date

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First of all, I thank God for his mercies, protection and giving me knowledge to complete this work. I would like to express my sincere gratitude to my supervisor, Dr. J.D. Gadze for his continuous support, advice and inspiration throughout my MSc Program. Without him, none of this would have been possible. Again, I would also like to thank Mr. Ayilari Naa Tuati, Mr. Odei Addo, Mr. Albert Amos, and Mrs. Mercy Amuzu all of Ghana Meteorological Agency. They willingly provided me with meteorological data of Ghana relevant for this thesis. I would also like to show my appreciation to the entire Department of Electrical Engineering for the commitment they showed to this thesis and the entire program. Last but not least, I would express my gratitude to my mother, Ms. Grace Sarpong for her support and prayers throughout my MSc. Program.

ABSTRACT

Free Space Optical (FSO) communication is the transmission of optical signals through the atmosphere. This technology promises high wireless data rates, highly secured transmission, license-free operation and immunity to electromagnetic interference. However, turbulent atmospheric conditions have impacts on its performance and therefore hampered its wide spread deployment. In this thesis, we investigate the feasibility of FSO in Ghana. Atmospheric attenuation is estimated based on the atmospheric visibility data. Our results show atmospheric specific attenuation as high as 128.2dB/km in the 1550nm window, 134.5dB/km in 1300nm window and 150.95dB/km in the 850nm window. The probability of encountering different atmospheric attenuation conditions is estimated. Fading loss due to scintillation is investigated using the lognormal statistical model. It is shown that the margin to compensate for losses due to scintillation depends on the power scintillation index and the allowable system outage probability. The system availability estimated in Ghana is above 99% for a propagation path of 1km.

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