

Analysis of Path Loss about Radio Duct Phenomenon with Atmospheric Refractive Index Information

Jinhyung Oh, Jong Ho Kim and Young-Jun Chong

Radio Resource Research Group

Electronic Telecommunications Research Institute (ETRI), Daejeon, Republic of Korea

E-mail : jinhyung@etri.re.kr, jonghkim@etri.re.kr and yjchong@etri.re.kr

Abstract— The radio duct phenomenon is one of the factors that explain the radio interference between neighbouring countries. When the signal transmitted from the coast passes through the sea surface, the attenuation of the signal is relatively reduced due to the ducting phenomenon, and the received signal is affected to be interfered with the receiver in the coastal area of the neighbouring country. The ducting phenomenon is caused by the refractive index reversal of the high-level atmospheric information, and the amount of interference varies depending on the depth and slope of the duct due to the atmospheric refractive index. In this paper, we analyse the atmospheric refractive index in a specific region and explain the occurrence of duct phenomenon through path loss simulation related to the region.

Keywords— Radio duct phenomenon, Atmospheric Refractive index, Neighbouring country interference

I. INTRODUCTION

In recent years, as the number of various devices using wireless communication has been explosively increased, a shortage of mobile communication and public frequency has been intensified. Accordingly, each country adjusts the frequency allocation according to frequency use through international standards. In some countries, the same and adjacent frequencies are used for each service considering the signal attenuation due to the distance. When each country uses the same and adjacent frequencies, the inter-country distance is somewhat small, so interference signal is not received, however, when the sea level is located in the middle, the signal attenuation is reduced due to the specific atmospheric phenomenon, and the interference signal is frequently occurred [1]-[3]. In order to minimize the interference caused by the unexpected interference, it is important to find the way to avoid the interference by analysing the cause of the weather such as the duct phenomenon. In this paper, we analyse the influence of radio propagation duct by introducing the basic understanding of radio duct phenomenon, the atmospheric refractive index analysis through high-level atmospheric information, and the path loss simulation result.

II. RADIO DUCT PHENOMENON

As described in the introduction, radio ducts are caused by differences in the temperature of the sea surface and the surface temperature. That is, since the temperature change of the sea

surface is smaller than the change of the temperature of the earth surface, the atmospheric refractive index is reversed, and this reverse phenomenon causes radio propagation duct. Originally, the term “duct” was derived from the term waveguide, meaning that the airwaves pass through the sea bed, which is held in the air layer, which serves as a waveguide, with little loss. The atmospheric refractive index is calculated as a function of various high-level atmospheric information, and the calculation formula is as follows.

$$\text{Modified Refractive Index} = \text{Refractive Index} + 0.157 \times h \text{ (Altitude)} \quad (1)$$

$$\text{Refractive Index} = \frac{77.6}{T} \times \left(P + 4810 \times \frac{V}{T} \right) \quad (2)$$

$$\frac{U}{100} \times 6.1121 \times \exp \left(17.502 \times \frac{t}{t + 240.97} \right), \quad (3)$$

U is relative humidity

$$T(\text{absolute temperature}) = t + 273 \quad (4)$$

The duct due to the meteorological phenomenon is roughly divided into four types. First, the evaporation duct is shown in Fig. 1, which is modeled as a logarithmic function.

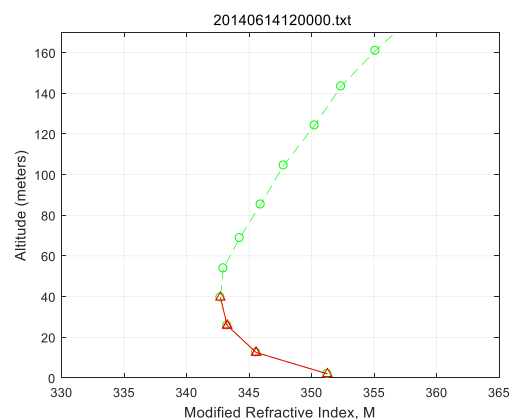


Figure 1. Evaporation Duct Results

Figure 1 shows the results based on the high-rise meteorological information measured at the meteorological station at 12:00 pm on June 14, 2014 in Pohang, Korea.

Secondly, similar to the evaporative duct, there may be surface ducts that are modeled as bi-linear curves. Figure 2 shows that ducts are modeled in a linear fashion, unlike Figure 1. The duct results identified in Figure 2 were derived on the basis of the results measured at the meteorological station of Pohang, Korea, at 12:00 pm on January 14, 2015.

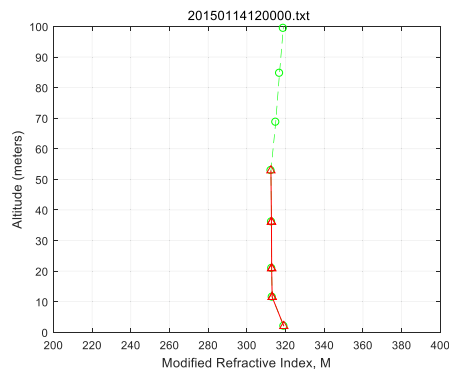


Figure 2. Surface Duct Results

The elevated duct refers to the case where the minimum altitude of the ducting depth is on the surface of the earth, as shown in the graph in Fig. 3.

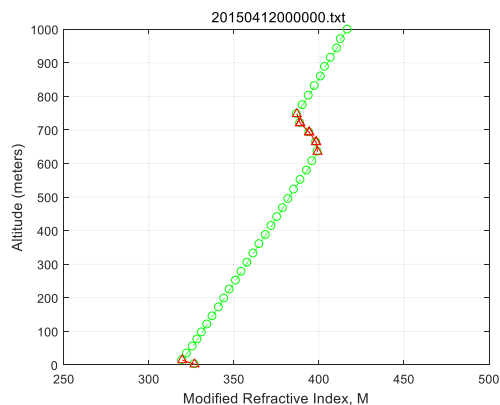


Figure 3. Elevated Duct Results

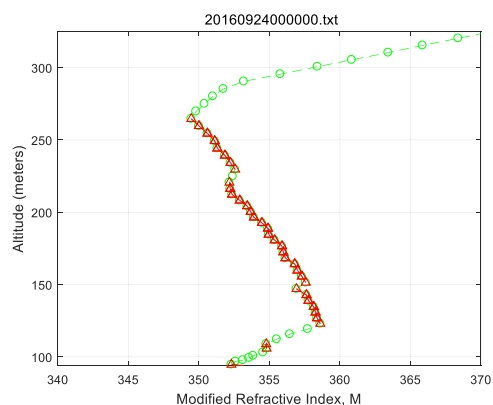


Figure 4. Surface based Duct Results

The duct results identified in Figure 3 were derived on the basis of the results measured at the meteorological station of Pohang, Korea, at 12:00 pm on April 12, 2015. Finally, there is a duct

called a surface based duct. The shape of the graph is almost similar to that shown in Fig. 3. The difference from the elevated duct is that the lowest altitude at which the duct occurs is below the surface of the earth. Figure 4 shows the results of the atmospheric refractivity derived from the meteorological information obtained at the meteorological station of the Heuksan Island in South Korea on September 24, 2016, and the above-mentioned surface based duct was generated. Since the elevation of the Meteorological Zone in the Heuksan Island area is about 90m, the starting point of the graph is about 90m.

III. SIMULATION RESULTS

In this session, we show the simulation result of the path loss change caused by the duct phenomenon. The simulation uses the AREPS program, which was used for the far-field radar program, and analyzed the airborne refractive index information of the Republic of Korea into the program. The path loss simulation results for the duct phenomenon were performed in the 2.5GHz band, and the antenna height was assumed to be 40m for transmission and 140m for reception. The distance between the transmission point causing interference in simulation and the point receiving interference is assumed to be about 182 km. The transmission point is assumed to be near Shimonoseki, Japan, and the reception point is assumed to be near the Busan city, Korea. The simulation results are as follows. First, we present the results of the simulation in the atmosphere where no duct is generated in order to present the criteria for checking the path loss due to the duct phenomenon.



Figure 5. Simulation Path between Korea and Japan

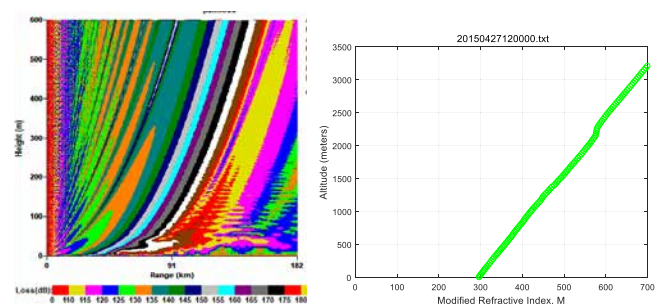


Figure 6. Path Loss Result for Normal Atmosphere

The path loss value according to this simulation derived from normal atmosphere is 204.6. Figure 7 shows the path loss graph according to the evaporation duct, and the path loss value according to the AREPS simulation is 170.6.

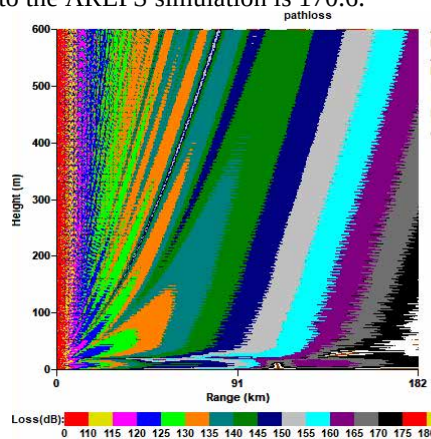


Figure 7. Path Loss Result for Evaporation Duct

Figure 8 shows the path loss simulation when the elevated duct occurs and the path loss value is 189.7.

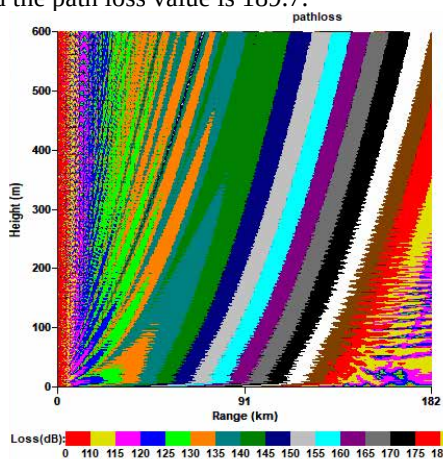


Figure 8. Path Loss Result for Elevated Duct

Figure 9 shows the path loss simulation when the surface duct occurs and the path loss value is 160.2.

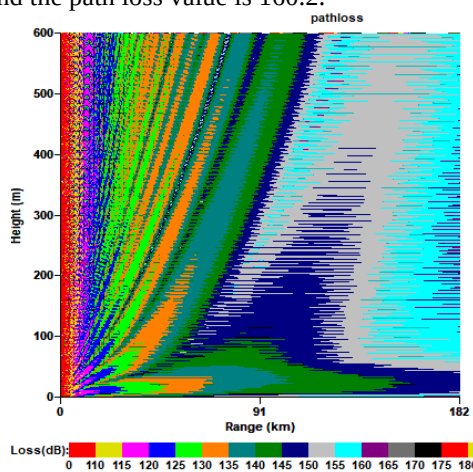


Figure 9. Path Loss Result for Surface Duct

Figure 10 shows the path loss simulation results for the surface based duct, and the path loss value is 149.3.

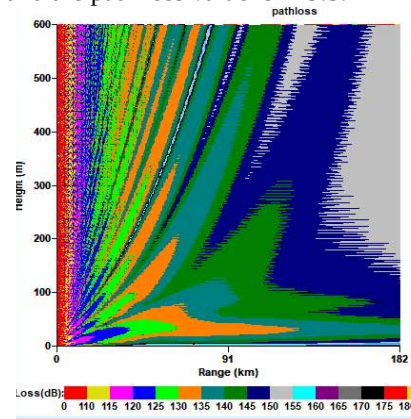


Figure 10. Path Loss Result for Surface Duct

The results of the AREPS path loss simulation using the atmospheric refractive index value in Pohang, Korea, and the ITU-R P.452 and free space loss results are summarized in the table below.

TABLE 1. FONT SIZES FOR PAPERS

Model		2.5GHz
Free space		145.6
ITU-R P.452	50 %	200.6
	10 %	163.7
	1 %	148.0
AREPS	Normal	204.6
	Evaporation Duct	170.6
	Elevated Duct	189.7
	Surface Duct	160.2
	Surface Based Duct	149.3

IV. CONCLUSIONS

In this paper, the atmospheric refractive index is derived based on the high - level atmospheric information in the Republic of Korea and the path loss results in the 2.5GHz band are derived through the AREPS simulation by applying the derived atmospheric refractive index. The types of ducts are divided into four types, and path loss results are variously derived depending on the types of ducts. In the future, we will elucidate the causal relationship between duct type, shape, and path loss.

ACKNOWLEDGMENT

This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (MSIP) (No.2017-0-00066,

Development of time-space based spectrum engineering technologies for the preemptive using of frequency)

The high-altitude weather data used in the calculation of the atmospheric refractive index of this paper for simulation was provided by the Korea Meteorological Administration.

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Jinhyung Oh received his B.S degree in Electrical Communications Engineering from Korea Advanced Institute Science and Technology (KAIST), Daejeon, in 2008 and M.S. degree in Electrical and Electronic Engineering from Korea Advanced Institute Science and Technology (KAIST), Daejeon, in 2010. In 2010, he joined the Electronic and Telecommunications Research Institute (ETRI) where he is a researcher of the Radio

Technology Department. His research interests include wireless communications, interference analysis and digital beamforming.



Jong Ho Kim received his BS, MS, and PhD in electronic engineering from Chungnam National University, Daejeon, Rep. of Korea, in 1986, 1988, and 2006, respectively. Since 1989, he has been working for ETRI, Daejeon, Rep. of Korea, where he is a principal member of the engineering staff of the Radio Technology Department. His main interests are radio propagation and spectrum engineering.



Young-Jun Chung received the B.S. degree from the Jeju University, Jeju Island, Korea, in 1992, and the M.S. degree in electronics engineering from Sogang University, Seoul, Korea in 1994, and Ph.D degree in Electronic Engineering from Chungnam National University, Daejeon, Korea in 2005.

Since 1994, he has been with ETRI, Daejeon, Korea, where he is a leader of spectrum engineering research and section principle member of the research staff of the Radio Technology Department. His research interests include RF circuit, RF systems, and spectrum engineering.