Investigation of the Effect of Ground and Air Temperature on Very High Frequency Radio Signals

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Abstract

This paper presents the results of the investigation of the effect of ground surface temperature and air temperature on the Very High Frequency (VHF) radio wave propagation by experimental method. The experimental measured data obtained were analyzed by regression technique. The results based on the best trendline shown that as the ground surface temperature increases, the loss (Path Loss) in the VHF radio signal reduces with gradient coefficient of 21.8dB/^{0}C. Also, the results shown that as the air temperature increases, the loss in the VHF radio signal reduces, however with very smaller gradient coefficient of 7.5dB/^{0}C than the ground surface temperature. The observation of Path Loss against increase in temperature is based on the weather condition when relative humidity (RH) is low. However, when the RH is high and the temperature is also high, the observation is relatively different. This is evident from another results which shown that as the RH increases, there is little increase in loss of the VHF radio signal, with gradient coefficient of about 2.32dB/^{0}C. This can be due to the effects of refraction, diffraction and scattering of the radio wave by the presence of the water vapor in the air when RH is high. Significantly, the results have shown that the VHF radio wave propagates through the ground surface more than the space (air) during the period under consideration.

Keywords: Ground surface, Air, Temperature, Path Loss, Very High Frequency radio

1. Introduction

Aside from building and Vegetation, weather is an additional factor that affects radio wave propagation. For instance, rain, wind, temperature, and water content of the atmosphere can combine in many ways to affect radio wave propagation. Certain combination may course radio signals to be heard hundreds of miles beyond the ordinary range of radio communication. Conversely, for instance different combination factors can cause such attenuation of the signal that it may not be heard even over a normally satisfactory path. Unfortunately, there are no hard and fast rules on the effect of weather on radio transmission since the weather is extremely complex and subject to frequent change. It is a well know scientifically that Very High Frequency (VHF) radio wave propagation takes two routes: ground and space (air). Several factors that can affect its propagation such as terrain, building, vegetations, weather parameters (such as rain, snow, haze and dust) have been studied by many authors (Wesolowski, 2002; Blaunstein *et al*., 2003; Seybold, 2005; Meng *et al*., 2009; Alade, 2013a; Alade, 2013b; Alade, 2013c). However the report of the effect of ground surface temperature and air temperature on radio propagation is very scarce in the literature.

Under normal atmospheric conditions, the warmest air is found near the surface of the earth. The air gradually becomes cooler as altitude increase in the troposphere section of the atmosphere. At times, however, an unusual situation develops in which layers of warm air are formed above layers of cool air. This condition is known as temperature inversion. These temperature inversions cause ducts of cool air such that radio wave is guided by duct over long distance beyond the expectation. However, the occurrence of such situation is not often. Air with a lot of water vapor in it is said to be humid. In science, scientists do not talk of how much water vapor is actually present in the atmosphere (air), but consider the saturation of air in terms of relative humidity (RH).

Due to the modes of propagation of Very High Frequency (VHF) radio wave (see Figure 1), there is possibility that ground temperature (GT) and air temperature (AT) can affect propagation of this radio wave. The typical experimental results of the investigation of effect of air temperature on radio propagation are very scarce in the literature. This paper therefore presents the investigation of the effect of ground surface temperature and air temperature on the VHF radio wave propagation by experimental method.

2. Materials and Methods

The experiment to verify the effect of ground surface temperature (GT) and air temperature (AT) on VHF radio wave propagation was carried out between the months of July, 2012 and April, 2013. The equipments employed for the experimental measurements are Automatic Weather Station (AWS) and GSP 810 Spectrum Analyzer. They were set up as shown in the Plates 1 and 2. The GSP 810 Spectrum Analyzer while measuring the received power level of a particular VHF radio station, about 12km away from the receiver, transmitting at 92.1MHz, 2.5kW is synchronized with the AWS from 7.00am in the morning to 9.00pm in the evening to observe variations in the ground surface temperature, and air temperature for the transmitting period of the VHF radio station. The measured data were collated for the period; July 2012 and April 2013.

3. Results and Discussion

In this paper, the study of investigation of the effect of ground surface temperature and air temperature on the VHF radio wave propagation by experimental method is presented. The measurement data obtained were collated and processed. The data were then analyzed by scatter plotting. The best lines (trendlines) were located based on regression analysis technique. Figure 2 is the plot of Path Loss (PL in dB) versus Ground surface Temperature (GT in ^{0}C). From the plot, based on the best trendline, it can be deduced that as the ground surface temperature increases, the loss (Path Loss) in the VHF radio signal reduces with gradient coefficient of about 21.8dB/^{0}C. Figure 3 is the plot of Path Loss (PL in dB) versus Air Temperature (AT in ^{0}C). Also, from the plot, based on the best trendline, it can be deduced that as the air temperature increases, the loss (Path Loss) in the VHF radio signal reduces, however with very smaller gradient coefficient of about 7.5dB/^{0}C than the ground surface temperature. The observation of Path Loss against increase in temperature is based on the weather condition when RH is low. However, when the RH is high and the temperature is also high, the observation is relatively different as shown in the Figure 4. Figure 4 is the plot of Path Loss (PL in dB) versus Relative Humidity (RH in %). From the plot, based on the best trendline, it can be deduced that as the RH increases, there is little increase in loss (Path Loss) of the VHF radio signal, with gradient coefficient of about 2.32dB/^{0}C. This can be due to the effects of refraction, diffraction and scattering of the radio wave by the presence of the water vapor in the air when RH is high. Significantly, the results have shown that the VHF radio wave propagates through the ground surface more than the space during the period (7.00am to 9.00pm from July 2012 to April 2013) under consideration.

4. Conclusion

In conclusion, this paper has shown that ground surface temperature and air (space) temperature have additional propagation loss effect on Very High Frequency radio wave propagation.

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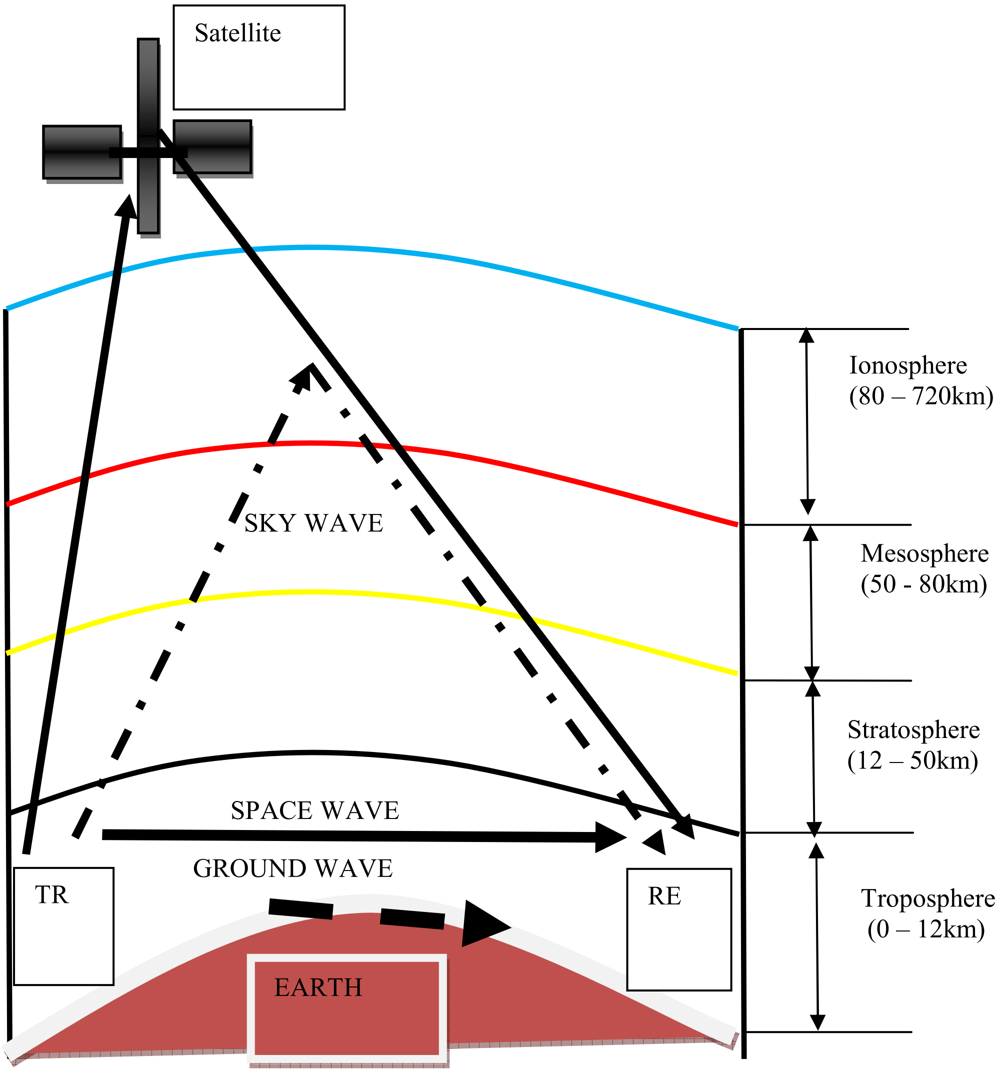

Figure 1: Showing different modes of radio propagation, TR is the transmitting station and RE is the receiving station.

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Plate 1: Showing the Automatic Weather Station (AWS) employed for temperature measurement.

Plate 2: Showing GSP 810 Spectrum Analyzer employed for the radio signal power level received.

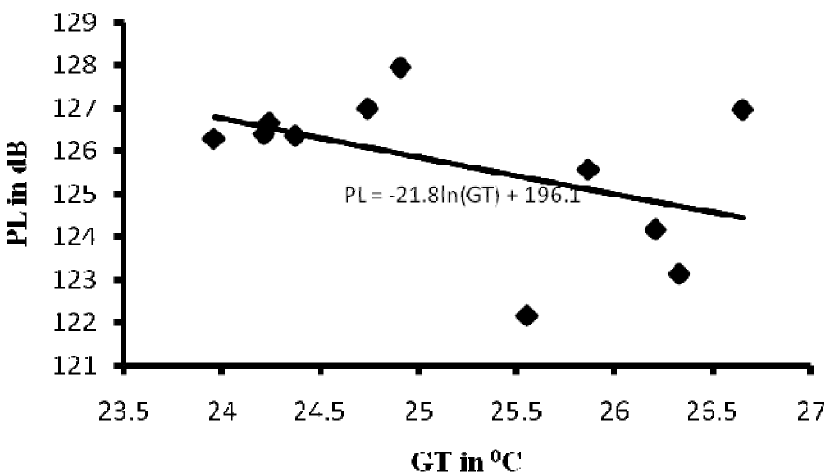

Figure 2: Showing the plot of the Path Loss (PL) versus Ground surface Temperature (GT).

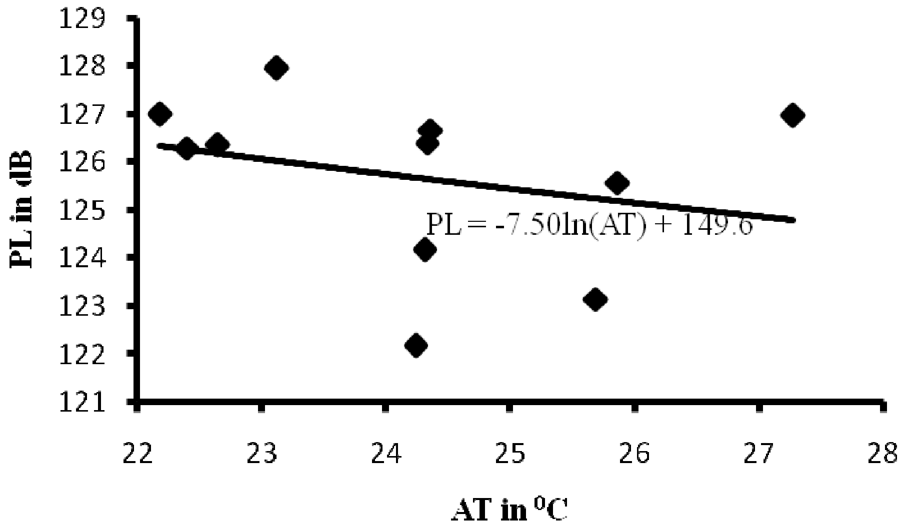

Figure 3: Showing the plot of Path Loss (PL) versus Air Temperature (AT).

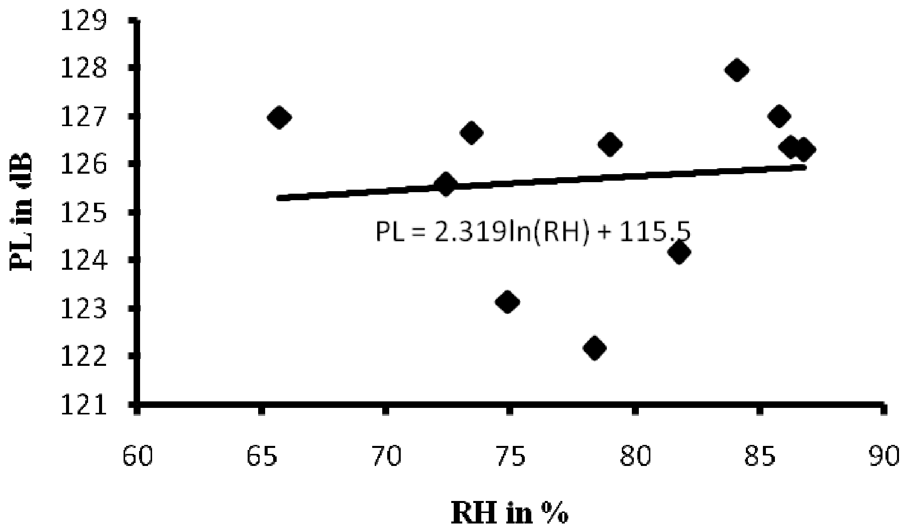

Figure 4: Showing the plot of Path Loss (PL) versus Relative Humidity (RH) for the period of the measurements.