Wind versus UHF Radio signal

Amajama Joseph, Daniel Effiong Oku

***Abstract*— Wind has been studied within the earth's troposphere and its effect on radio signal erected. Experiments have been carried out in a residential area (Etta-abgor) in the Calabar metropolis, Nigeria with the UHF (35mdB, 519.25 MHz) radio signal transmitted from the Cross River Broadcasting Cooperation Television (CRBC-TV) measured with a Cable-TV-analyzer and simultaneous measurement of the atmospheric components: temperature, pressure, humidity and wind (speed and direction) by the relevant apparatus. Results registered show that at uniform atmospheric temperature, pressure and humidity, wind has a marked effect on radio signal. The signal transmits better if the wind propagates in a similar path as the signal, but worse in the contrary directions. That is, the speed of the wind aids signal travel to some little extent if it is coursing parallel to the signal, but becomes detrimental when tangential or anti-parallel.**

***Index Terms*—Atmospheric components, Radio signal, Ultra High Frequency (UHF), Wind.**

I. INTRODUCTION

Wind is the flow of gases on a large scale. On the surface of the earth, wind consists of massive movement of air [8]. Winds are commonly categorized by spatial scale, types of forces that initiate them, their effects, speed and regions in which they occur. Winds have various aspects, an important one being its speed; another is the density of the gases involved and the energy content or wind strength [8].

Meteorologically, winds are often referred according to their strength and the direction from which they blow. Gusts are short bursts of high speed wind. Squalls are strong winds of intermediate duration (within a narrow window of a minute). Breeze, gale, storm and hurricane are the various terms associated with the average strength of long-window winds.

Winds take place on a compass (or range) of scales, from thunderstorms to local breeze to global winds. Most weather occurs at the troposphere or the lower sphere of the atmosphere [10]. Each of these factors: air temperature, pressure, humidity and wind can be measured to define typical weather patterns and determine the quality of local atmospheric conditions [8], [10].

Wind is caused by differences in the atmospheric pressure. When a difference in atmospheric pressure exists, air moves from the higher to the lower pressure regions, resulting in winds of various speeds. Wind speed is the distance which the wind in a region covers with time. It is also the average velocity of the atmosphere over a 5 mins period measured in miles per hour [11]. It is measured by an anemometer, commonly using rotating cups or propellers [8]. Wind run is the total distance that the wind has travelled during a particular time in a particular direction [11]. Wind direction is usually expressed in terms of the direction from which it originates [3]. In other words, wind direction is the direction in which the wind is coming from, measured in the degrees of a compass [11]. Weather vanes pivot to indicate the direction of the wind [1]. The Beaufort wind force scale provides an empirical description of wind speed based on observed sea conditions. Originally, it was a 13-level scale, but during the 1940s, the compass of the scale was extended to 17 levels [12].

The atmosphere plays an important role in radio communications [2] [4] [9]. The atmosphere is a medium for which radio waves propagate. Michelson Morley experiment was used to prove that light does not really need a medium to propagate [13]. However, the conditions of the medium for example when its particles are obstructive can have a negative impact on the speed of light and similarly other members of the electromagnetic spectrum, radio wave inclusive: since they share similar properties with the exception of penetration power. Like light, the atmospheric condition can lead radio waves to reflect or diffract or refract [7]. Diffraction or refraction can impinge on the speed of a radio wave.

Researches done on the effect of wind on radio are near none. The condition of the atmosphere or weather has been studied by a negligible few to have an effect on radio communications. The factors that constitute the condition of the atmosphere or weather are basically, the atmospheric temperature, pressure, humidity and wind [10]. Wind contributes to the refraction of the atmosphere together with diffraction [8]. Meng et al. (2009) had carried out a research on "The effects of tropical weather on radio wave propagation over foliage channel" and submitted that: the strength of wind conspired by rain can cause an additional increase in the attenuation of signal in such a channel [6].

This paper seeks to erect that wind has an effect on radio waves as they propagates through the atmosphere within the compass of the troposphere by depending on a signal of 519.25 MHz (UHF) and strength of 35 mdB transmitted from Cross River Broadcasting Television (CRBC-TV).

II. METHODOLOGY

The campaign was carried out in a residential area (Etta-abgor) within the Calabar metropolis in Cross River

Manuscript received Dec, 2015.

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ISSN: 2278 – 7798

State, Nigeria. Signal strengths were obtained every 30 mins at the residential area for over 24 hrs and simultaneously, the weather parameters: atmospheric or tropospheric temperature and pressure with relative humidity and wind direction and speed were recorded to probe the effect of wind on radio wave. The measurement of the signal strength was made using the Digital Community Access (Cable) Television (CATV) analyzer with 24 channels, spectrum 46 – 870 MHz, connected to a domestic receiver antenna of height 4.23m.

To be able to reach a justifiable conclusion on the impact of wind on the radio wave, the dependence of the signal strength on relevant atmospheric parameters aforementioned were analyzed. The received signal strengths were measured only on the downlink and the receiver antenna was adjusted until the best obtainable results of signal strength were captured on the cable analyzer before recording.

III. RESULTS AND DISCUSSION

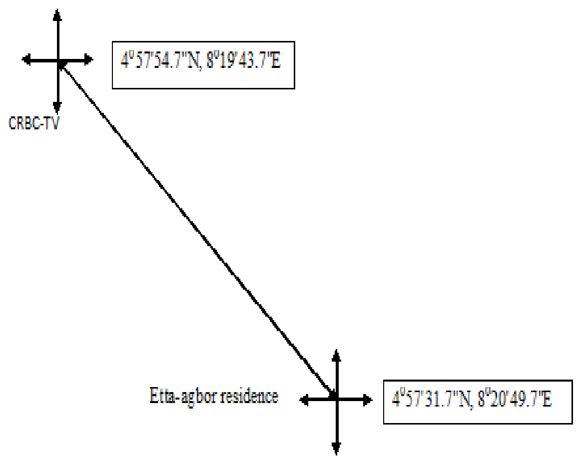

Fig. 1. Diagram showing the direction of CRBC-TV away from the Etta-abgor residence.

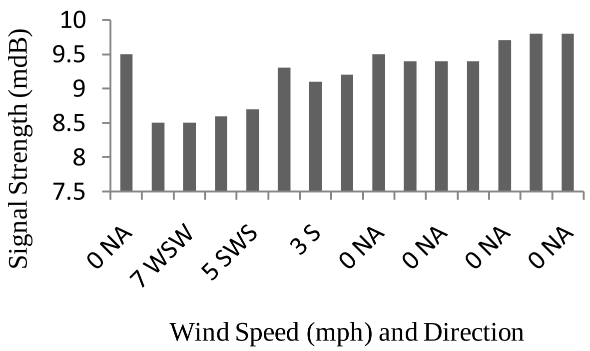

Fig. 2. Signal strength versus wind speed and direction at uniform temperature of 25^{0}C, uniform pressure of 1010.8 ($\pm$ 2.1) hpa and uniform humidity of 94%.

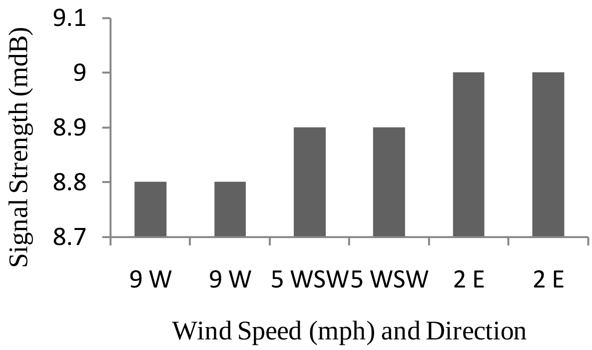

Fig. 3. Signal strength versus wind speed and direction at uniform temperature of 26.1^{0}C, uniform pressure of 1011.9 ($\pm$ 14.9) hpa and uniform humidity of 94 %.

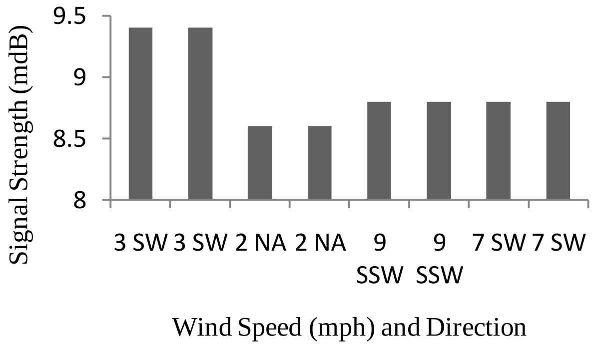

Fig. 4. Signal strength versus wind speed and direction at uniform pressure of 1010.8 hpa, uniform temperature of 26.4 ($\pm$ 0.8) ^{0}C and uniform humidity of 89 %.

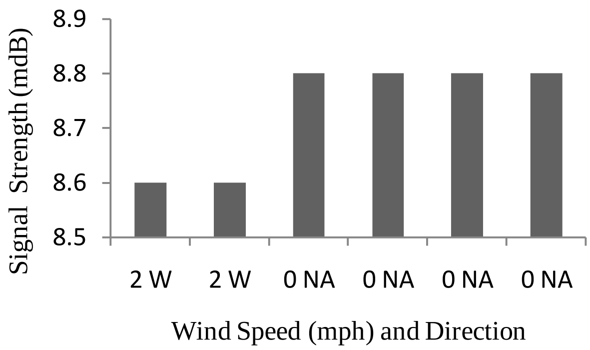

Fig. 5. Signal strength versus wind speed and direction at uniform temperature of 25 ^{0}C, at uniform pressure of 1012.9 hpa and humidity of 100 %.

Fig. 1 shows the location diagram of the residential area (Etta-abgor) and the CRBC-TV where the signal was transmitted. It is obvious from their longitudes and latitudes the residence is lying to the south east of the TV station. Also, they are 2 km apart in a direct or line of sight direction.

Fig. 2 shows a graphical representation of the signal strength against the wind in the residence at uniform temperature, pressure and humidity of 25 ^{0}C, 1012.9 ($\pm$ 2.1) hpa and 94 % respectively. It was observed that the maximum reading of the signal strength were recorded when there was no effect from the wind, which is 0 NA mph. There was a degradation of the signal strength as the wind speed

ISSN: 2278 – 7798

increased. The signal degradation was lesser at 3 S mph, higher at 5 WSW mph and highest at 7 WSW mph. This is owing to the fact that the speed of the wind in the southern direction is 3 mph, lesser than that of the west south western directions which are 5 mph and 7 mph respectively. Also, the southern direction is closer or next to the south east, but farther from the west-south-western direction. This south east direction is where the receiver antenna was positioned. For the 5 mph WSW and 7 mph WSW, the degradation was higher in the latter because the former has a lower wind speed. The higher the speed in a contrary direction: the higher the signal degradation.

Fig. 3 shows a graphical representation of the signal strength against the wind in the residence at uniform temperature, pressure and humidity of 26.1 ^{0}C, 1011.9 ($\pm$ 14.9) hpa and 94% respectively. The maximum signal strength captured was at 2 E mph. This due to the signal transmitted, propagating in a near similar direction as the wind, since the receiver lied south east of the transmitter. The signal degraded at 5 WSW mph and 9 W mph, since the directions of the wind are near opposite the direction of the propagating signal. None the less, the degradation of the signal was similar, despite the difference in the speed of the latter from the former where the latter is higher, even though the western direction is farther from the west south western direction.

Fig. 4 shows a graphical representation of the signal strength against the wind in the residence at uniform temperature, pressure and humidity of 26.4 ($\pm$ 0.8) ^{0}C, 1010.8 hpa and 89 % respectively. Here, the signal strength was a maximum at 3 SW mph since it was close to the direction of propagation of the wave to the receiver antenna which is in the south eastern direction. There is an equal degradation of the signal at 9 SSW mph and 7 SW mph despite the difference in speed and direction. This is in consequence of the former running close to the direction of the traveling signal path to the receiver antenna than the latter, but the latter possessed a lesser speed. The higher the speed in the contrary direction of propagation path: the more detrimental the degradation of signal. However, the maximum signal degradation was registered at 2 NA mph by virtue of omni-directional transmission of the wind and there was heavy fluctuation.

Fig, 5 shows a graphical representation of the signal strength against the wind in the residence at uniform temperature, pressure and humidity of 25 ^{0}C, 1012.9 hpa and 100 % respectively. The Cable analyzer registered the highest value at 0 NA mph, but less at 2 W mph which is near opposite the propagating path of the radio wave to the receiver antenna i.e. the south eastern direction.

IV. CONCLUSION

In this campaign, it has been erected that wind has a marked effect on radio signal. The signal transmits better if the wind propagates in a similar path as the signal to the receiver antenna, but worse in the contrary directions. Also, the speed of the wind aids signal travel to some little extent if it is coursing parallel to the signal, but becomes detrimental when the wind is tangential or anti-parallel. In a clearer light, the wind speed has a direct proportional relationship with the strength of the signal if both are travelling in a parallel direction to the receiver antenna, but an inverse proportional relationship when it is in a tangent.

REFERENCES

[1] *Glossary of meteorology*, "Wind vane", American meteorological society, Retrieved 7th November 2015, 2009.

[2] P. Ian (Ed.), "Radio signal path loss", Retrieved 3rd April 2015, from www.radio-electronics.com, 2015.

[3] *How to read weather maps*, National weather service, Retrieved 16th November 2015, 2008.

[4] S. S. John, *Introduction to RF propagation*, New York: John Wiley and Sons, 2005.

[5] S. C. Liew, "Principles of remote sensing", Retrieved 15th January 2015 from http://www.crisp.nus.edu.sg/-research/tutorial/em.htm, 2015.

[6] Y. S. Meng, Y. H. Lee & B. C. Ng, "The effects of tropical weather on radio wave propagation over foliage channel". *IEEE transaction on vehicular technology*, vol. 58, no. 8, pp. 4023 – 4030, 2013.

[7] T. S. Rappaport, *Wireless communications*. New Jersey: Pearson Prentice Hall, pp. 495 -502, 1996.

[8] "Tropospheric propagation", In Wikipedia, Retrieved 5th April 2015, from http://en.wikipedia.org/wiki/tropospheric_propagation, 2015.

[9] T. Wayne, Electronic communications systems, fundamentals through Advance, New Jersey: Prentice-Hall, pp. 39, 2001.

[10] "Weather versus propagation", *Introduction to wave propagation, Transmission lines, and Antennas*, Retrieved 5th November, 2015 from www.tpub.com/neets/book10/40c.htm, Port Richey-Hwy: Integrated publishing inc., 2015.

[11] "Weather parameters", Retrieved 10th November, 2015, from cees.tamiu.edu/cees/weather/parameters.html, 2015.

[12] "Wind", In Wikipedia, Retrieved November 10, 2015, from en.wikipedia.org/wiki/wind, 2015.

[13] H. D. Young & R. A. Freedman, *University physics* (9thed.). California: Addison-Wesley Longman, pp. 958-960, 1998.

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ISSN: 2278 – 7798