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Comparative Analysis of Atmospheric Horizontal Visibility and Meteorological Variables in the Niger Delta Region Nigeria

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Abstract
This work represents a comparative study of monitored atmospheric horizontal visibility datasets from (NIMET) over the Niger Delta region Nigeria (4.15N-7.17N, 5.05E-8.68E) using six locations (akure, warri, Owerri, Uyo,calabar and Portharcourt) within the area for a period of 31 years between 1981-2012, and Monthly mean datasets of meteorological parameters such as wind speed and relative humidity from National Centre for Environmental Prediction (NCEP) for the same period extracted with the grid analyses display systems (GRADS). The objectives were to compare the trends and also highlight their similarities and differences and to also examine how these data sets compare with each other in representing the region. The three datasets show significant similarity in the trends of visibility variability at each of the locations with decreased visibilities for Portharcourt, Uyo and Calabar and increased visibilities in Akure, Owerri and Warri respectively. The annual visibility variability indexes from (NIMET) shows significant correlation with the (NCEP) datasets for R/humidity at $r = 0.1334$ and Wind direction at $r = 0.1210$ respectively at 90% confidence level from t-test. The study will guide researchers in carrying out studies independently over the Niger Delta region Nigeria.
Keywords: Comparison, Visibility, Meteorological, Parameters, Variables and Niger Delta.

1. INTRODUCTION.

Visibility degradation as an environmental issue has become of public concern in Nigeria as evident in the Niger Delta Region. Its impairment is not just an aesthetic problem but could also be used as a visual indicator of ambient air quality in urban areas (1). Meteorological parameters such as relative humidity and wind speed/direction are natural causes of changes in visibility in the atmosphere and our environment. Manmade pollutants from combustion, construction, mining, agriculture and welfare are increasing by day thereby causing pollution. Atmospheric pollution due to coal combustion, vehicle exhaust and industry, which are known as the primary emission sources of particles over urban areas were considered to be the main cause of visibility degradation (2). This severe environmental problem has widely impacted on the people's lives, traffic, climate and other important aspects of human existence (3; 4; 5; 6, 7a,b). Visibility in urban areas has different characteristics on account of the changing meteorological factors depending on the geographical and topographical peculiarities of the urban area in discuss. The level of the visibility concentration is correlated with the combination of the various meteorological factors. For that reason the visibility concentration and meteorological factors should be evaluated statistically in order to correlate them (8).

Due to global climatic effects, the atmospheric aerosol is one of the important forcing factors responsible for global change and has become one of the important fields that have caused wide concern amongst scientists in recent years (9,10, 11). Due to increased urbanization and industrialization the Niger Delta joins other developing economies in the world to face air pollution as a common problem facing the globe and also one of those in Nigeria in which the aerosol is causing serious air pollution with large amount of land being exploited on the industrial scale, decreased traffic and vigorously developed township factories and workshops in the region, episodes of air pollution happen very often that they have aroused much concern in the government and the general public.

There has been series of methods applied to ascertain the relationships between variables by using some statistical techniques given a set of observations from air monitoring and meteorological stations. Some statistical models establish how close the relationships are between concentration estimates and values actually measured under similar circumstances (12). There are some studies in literature which investigate the air pollution in some big cities around the world such as Paris (13), Ravenna (14) and Shangai (15). Also (16) performed a study to show the influence of some meteorological factors on air pollution in Trabzon city in Turkey. They used SPSS code to make statistical analysis and obtained correlations for SO_2 and particle concentration between meteorological factors.

Their results indicated that there is a moderate and weak level of relation between the SO_2 level and the meteorological factors in Trabzon city.

In the study presented by (17), the relationship of SO_2 concentrations to six major meteorological parameters has been investigated and there result found out that SO_2 concentration strongly related to colder

temperature, higher relative humidity and lower wind speed.

The objectives of this work therefore is to perform a comparative analysis of horizontal mean monthly visibility data and monthly mean meteorological parameters of relative humidity and Wind direction over the Niger Delta region of Nigeria, highlightening their similarities and differences as well as to examine how these data sets compare with each other over the region.

1.1 STUDY AREA:

Figure one shows the map of Nigeria indicating the Niger Delta states. The Niger Delta area in Nigeria is situated in the Gulf of Guinea between longitude (5.05E-7.17E and latitude 4.15 N- 7.17 N). It is the largest wetland in Africa and the third largest in the world consisting of flat low lying swampy terrain that is cress crossed by meandering and anatomizing streams, rivers and creeks. It covers 20,000km^2 within wetlands of 70,000km^2 formed primarily by sediment depositions. It constitutes about 7.5% of Nigeria's land mass with an annual rainfall total averaging from 2400-4000mm. The area is influenced by the localized convection of the West African monsoon with less contribution from the mesoscale and synoptic system of the Sahel (18). The rainy (wet) season over the region starts in May, following the seasonal northward movement of the Intertropical Convergence Zone (ITCZ), with its cessation in October (19; 20). It has an equatorial monsoon climate influenced by the south west monsoonal winds (maritime tropical) air mass coming from the South Atlantic Ocean. It is home to 20 million people drawn from nine states of the federation namely Abia, Akwa-ibom, Bayelsa, Cross- River, Delta, Edo, Imo, Ondo and Rivers states with 40 different ethnic groups, its often regarded as the hub of Nigeria's oil production. This flood plain makes 7.5% of Nigeria's total land mass (21). The study is restricted to six states in the Niger Delta namely warri, Owerri, Calabar, Akure, Uyo and Portharcourt because there are no available data in the remaining stations Yenegoa, Umuahia and Asaba as shown in Table 1 below.

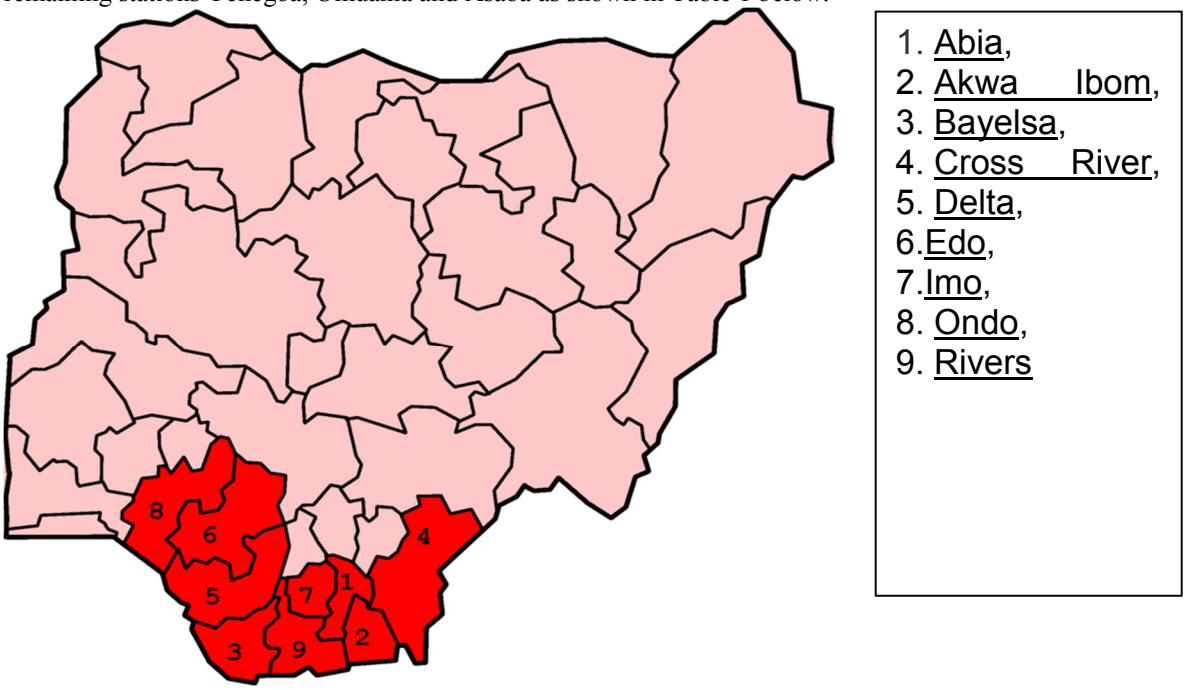


Fig 1: Map of Nigeria showing the Niger Delta region (5.05E-8.68E and latitude 4.15 N – 7.17 N) shaded with colors.

TABLE 1: Cordinates of the study locations, their elevations and duration of study.

STATIONS/LOCATIONS	*LAT(N)*	*LONG (E)*	*ELEVATION (M)*	*DURATION*
AKURE	*7.247*	*5.301*	*335.0*	*1981-2012*
CALABAR	*4.976*	*8.347*	*63.0*	*1981-2012*
OWERRI	*5.483*	*7.033*	*91.0*	*1981-2012*
PORTHARCOURT	*4.750*	*7.016*	*18.0*	*1981-2012*
WARRI	*5.516*	*5.750*	*8.0*	*`1981-2012*
UYO	*5.038*	*7.909*	*196.0*	*1981-2012*

1.1.1 METHODOLOGY

A 31 years record of observational data between (1981-2012) of mean horizontal visibility for some coastal weather stations in the Niger Delta Region Nigeria, Warri (5.75E, 5.52N), Owerri (7.03E, 5.48N), Calabar (8.32E, 4.95N), Akure (5.19E, 7.25N), Uyo (7.91E, 5.03N) Portharcourt (7.00E, 4.75N) were obtained from Nigerian

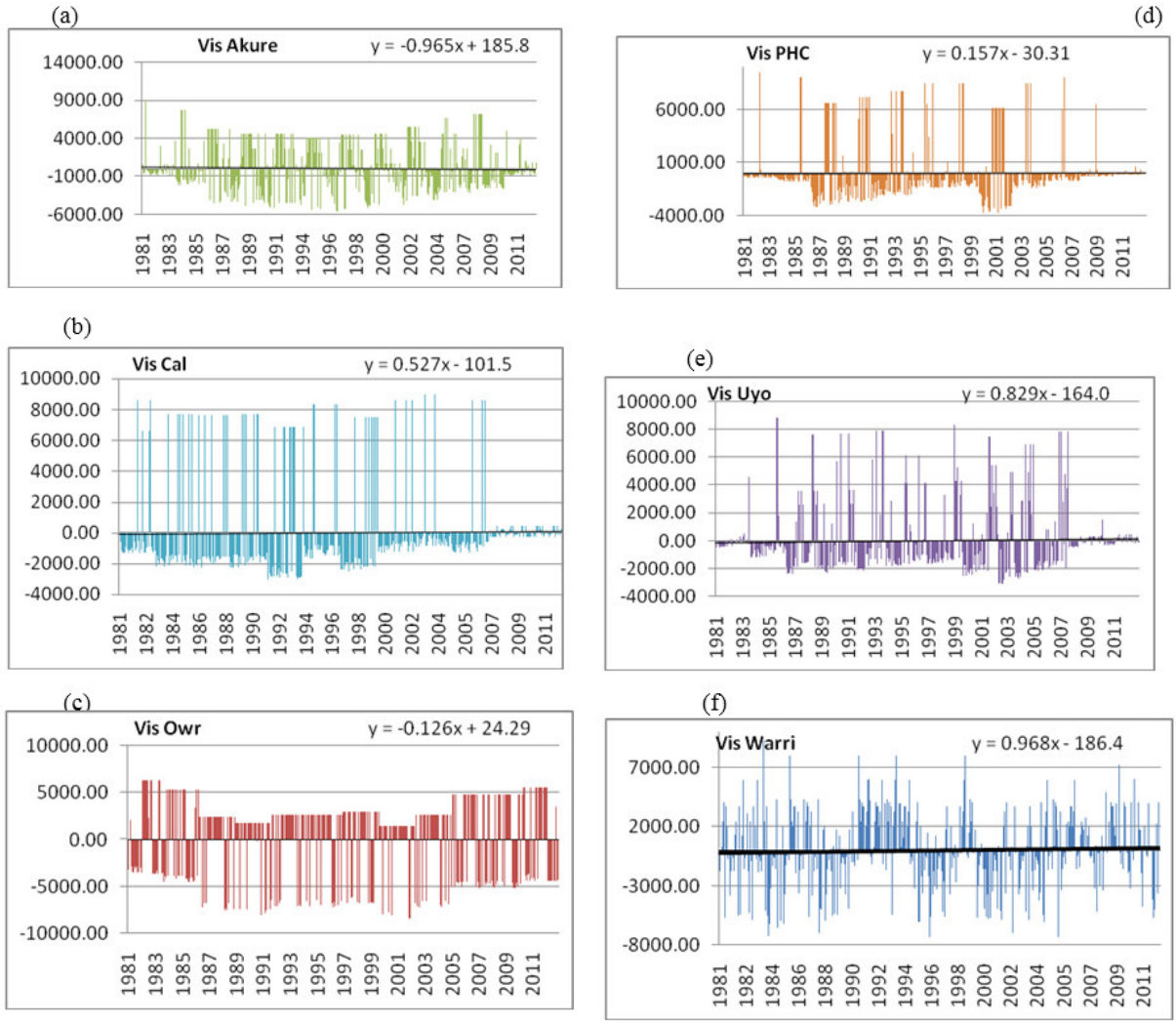
Meteorological Agency Abuja (NIMET) which is the agency responsible for collecting and archiving meteorological data in Nigeria and reanalysis data for wind direction and relative humidity for the period (1981-2012) from the National Centre for Environmental Prediction (NCEP) and its available online at (http://www.ncep.noaa.gov) which were also extracted using Grid Analysis Display system (Grads) prepared on a resolution of 2.5˚ by 2.5˚ global grid (approximately 180km) . However statistical time series criteria for the analysis have been followed.

1.2 RESULTS AND DISCUSSION

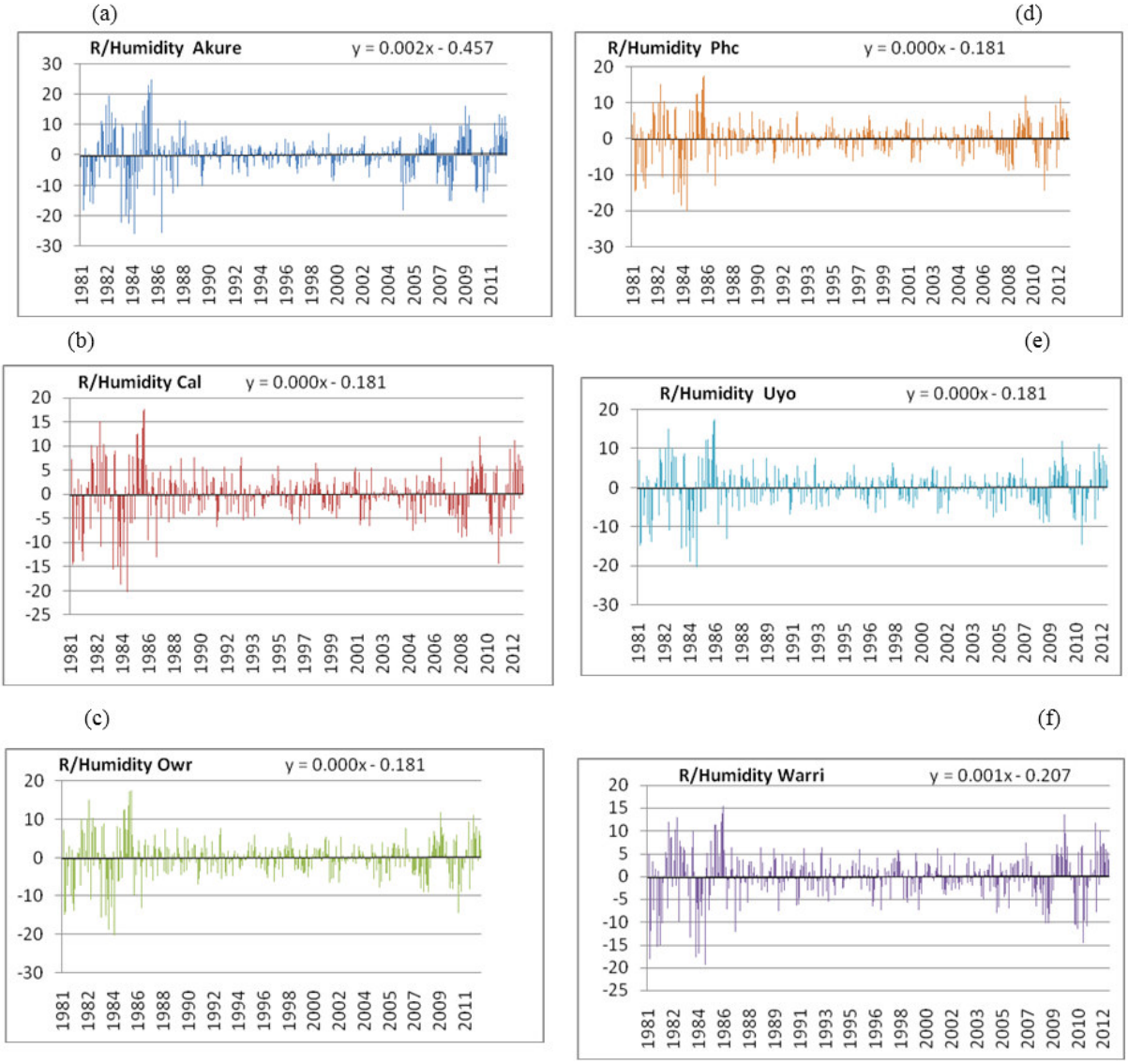
Similarity and differences on Visibility, Relative Humidity and Wind Direction.

Due to the resolution of the Datasets, NCEP has a grid box representing each of Relative humidity and wind direction. Figures 2 (a-f), 3 (a-f) and 4(a-f) shows the time series of the normalized monthly datasets for visibility, relative humidity and wind direction anomalies from the three datasets at each of the locations. The relative humidity and wind direction shows similarities to visibility dataset at each station. This is evident in the coefficient of correlation values of NIMET data with NCEP data respectively which is significant at 90% confidence level from t-test. However the correlation values were higher with the (NCEP) datasets relative humidity than wind direction. The linear regression equation for the three datasets indicate that the monthly variability for the three locations showed positive upward movements for the stations except for the relative humidity which shows negative movements for all the locations.

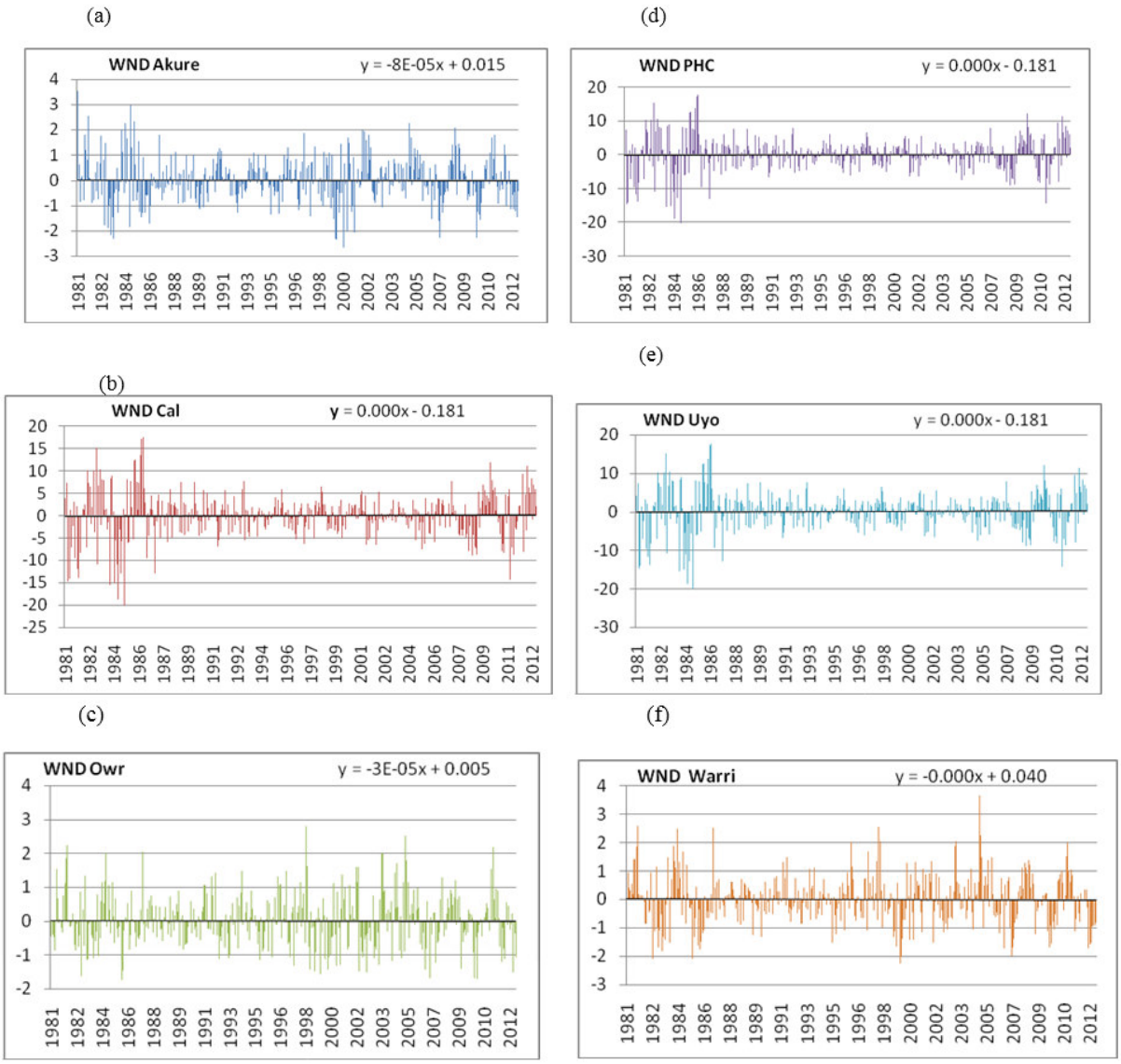
Figure 5 (a-c) shows the time series of the normalized areal averages of the monthly anomaly over the Niger Delta region of Nigeria from the NIMET and the NCEP datasets. The trends of the three datasets confirm increment in the monthly variability over the region with varying magnitudes. The coefficient of correlation of the normalized areal average shows that the variability from NIMET has significant relationship with NCEP datasets Relative humidity $(r = 0.1344)$ and Wind direction $(r = 0.1210)$ respectively both at 90% confidence level from t-test.



Fig, 2(a-f): Represents Normalized time series of Visibility anomalies from (NIMET) at (a) Akure, (b) Calabar, (b)Owerri, (d) Phc,(e) Uyo and (f) Warri. The linear regression equation of the trends is above each panel.



Fig, 3(a-f): Represents Normalized time series of relative humidity anomalies from (NCEP) at (a) Akure, (b) Calabar,(c)Owerri, (d) Phc,(e) Uyo and (f) Warri.
The linear regression equation of the trends are above each panel.



Fig, 4(a-f): Represents normalized time series of Wind direction anomalies from (NCEP) at (a)Akure, (b)Calabar, (c)Owerri, (d)Phc,(e)Uyo and (f)Warri. The linear regression equation of the trends is above each panel.

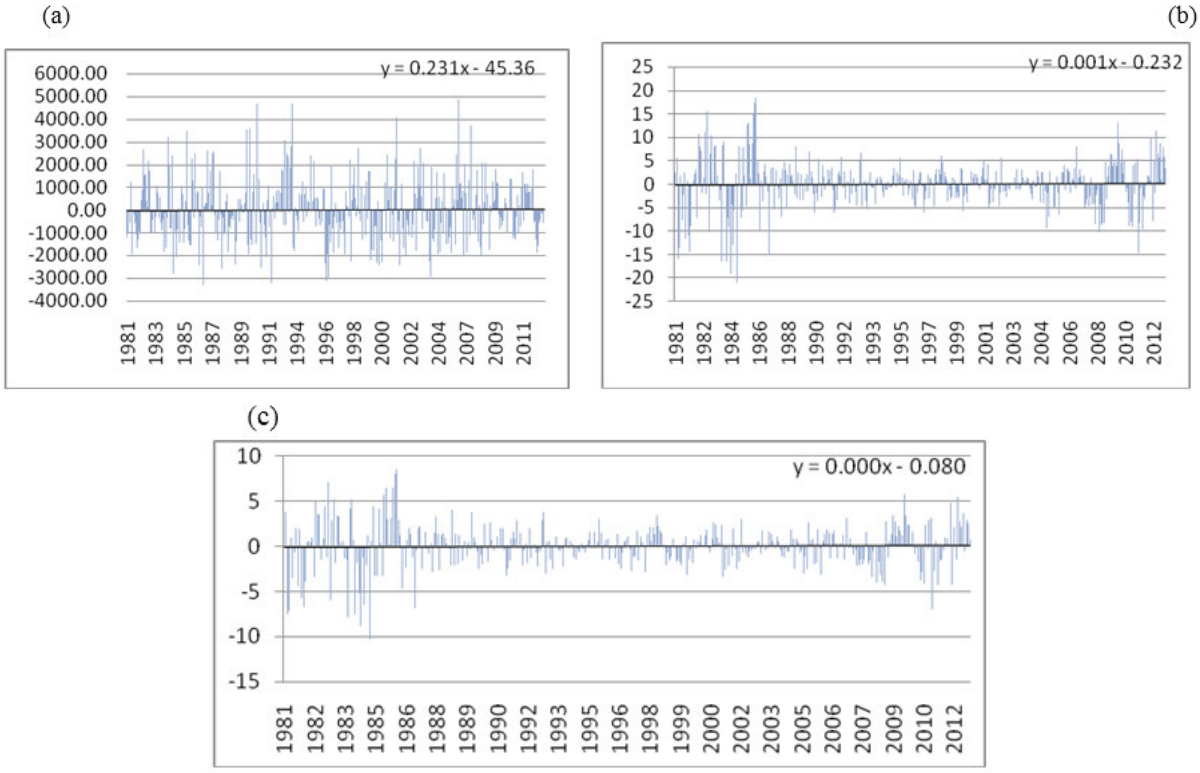


Fig 5 (a-c): Normalized time series of (a) Visibility, (b) Relative humidity, (c) Wind Direction for the areal averaged monthly anomaly over the Niger Delta region and the linear regression equation of the trends are above each panel.

The mean detrended series was used to estimate the seasonal indices and seasonal effect of Visibility, Relative humidity and Wind direction over the locations in the study area which complies with the fact that the sum of the seasonal effect of an additive model over a complete cycle equals to zero. The seasonal indices of the study shows that visibility recorded increase in Warri, Owerri and Akure of 2.056817, 1.523725, 0.988518 respectively and a corresponding decrease in Uyo, Calabar Portharcourt at -3.87354, -0.08079, -0.6144 respectively. Relative humidity has a positive upward movement and presence of peaks and troughs which indicate variation and the seasonal indices of (0.006192, 0.003715, 0.001239) for Warri, Owerri and Akure respectively and (-0.00124, -0.00372, -0.00619) for Uyo, Calaber and Portharcourt respectively. The Wind direction also recorded increase in Warri, Owerri and Akure at (2.056817, 1.523725, 0.988518) respectively and decrease in Uyo, Calaber and Portharcourt at (-3.87354, -0.08079, -0.6144) respectively. The atmospheric visibility is positively related to prevailing wind direction of the place of observation such that one can say that atmospheric visibility improves if the wind speed becomes high and vice versa, reason being that if wind speed is high it will carry away the air pollutants with it and thus helps in improving the visibility of a place. Relative humidity of a place is negatively related to atmospheric visibility such that when humidity increases there will be formation of tiny droplets suspended in air which reduces the atmospheric visibility by inhibiting the solar radiations reaching the earth surface, this can be seen in figure 3(a-f).

CONCLUSION:

This study has compared the similarities and differences between horizontal visibility and measured meteorological parameters (Relative humidity and wind direction) this was carried out in six locations over the Niger Delta region of Nigeria for the period of 31 years. Since the NCEP datasets are products of different interpolation technique, whereas the visibility datasets from NIMET are presented as observed, differences and similarities are anticipated from the output. The results of the comparative analysis indicate that there is a good measure of agreement between atmospheric horizontal visibility (NIMET) dataset and NCEP dataset at each of the location as well as on the areal average over the region. The correlation between the areal averaged monthly datasets of both NIMET and NCEP at each location shows the signature of the sets at each location. Though the three datasets show increment in the trend for Akure, Owerri and Warri and a corresponding decrease for Porharcout, Uyo and Calabar respectively. This comparison does not provide all the uncertainties that would be found from each of the datasets over the Niger Delta Region but it's a measure of the expected minimum uncertainties in the datasets which should guide researchers and scientists carrying out research and studies on regions of this scale. However further investigation into the implications of using other meteorological parameters

within the region should be considered.

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