International Journal of Humanities and Social Sciences
p-ISSN: 1694-2620
e-ISSN: 1694-2639
Vol. 8 No. 3, pp. 1-20, ©IJHSS

Assessing the relationship between climate and patterns of wildfires in Ghana

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Abstract

Wildfires are a common occurrence in many areas with a distinct dry season. The objective of this study is to investigate the relationship between wildfires (bushfires) and the climate in Ghana. I establish the correlation between fire data, mean monthly temperatures and average monthly precipitation. I also assess the pattern of wildfire occurrence in Ghana with respect to the pattern of movement of the Intertropical Convergence Zone (ITCZ). Using climate data for period November 2000 to March 2010 at a 0.5° by 0.5° resolution, from the University of East Anglia's Climate Research Unit (UEA CRU TS3.23), and MODIS Climate Modelling Grid (MOD14CMH) Active Fire Products at a 0.25° by 0.25° resolution, obtained from the Active Fire Products data maintained by the University of Maryland, also from November 2000 to March 2010, it was found there is no meaningful correlation between the fire data and individual mean monthly temperatures and average monthly precipitation. However, there is a strong relationship between the pattern of fire occurrence and the pattern of movement of the ITCZ in Ghana. I conclude that there is a strong relationship between wildfire occurrence and climate in Ghana based on the closeness of the relationship between the movement of the ITCZ and the pattern of wildfire occurrence.

Key words: ITCZ, harmattan, bushfires/wildfires

Introduction

Wildfires are a common occurrence in areas with a high amount of vegetation and a period of dryness in the course of the year (Balling, Meyer & Wells 1992). The more foliage there is in an area, the more fire there is likely to be, all other things being equal (Agee 1998, cited in McKenzie et al. 2004). The vegetation amount and type, and the weather conditions which creates a 'fire weather' is determined by the type of climate (Heyerdahl, Brubaker & Agee 2002). This implies that the more moisture there is in the atmosphere, the less risky there is for a possible ignition and vice versa.

Ghana lies within the tropical zone and hence has high temperatures for most of the year, with distinct periods of dry season and wet/rainy seasons in the year, which vary from the north to the south, in line with the variations in the climate (McSweeney et al. 2010). The northern part of the country has a guinea savanna type of vegetation where there are high temperatures all year round and a long dry season, and the southern part has a short dry season with the rainy season divided into a major and a minor rainy season (McSweeney et al. 2010). The climate of an area is fairly fixed, and so the risk of an area getting burnt depends on the weather. In addition to the weather, the risk of ignition depends on the fuel load (amount of dry vegetation) (Bowman et al. 2009). Therefore, climate and weather determine the trends of wildfires in an area, and so any changes in the climate will affect the pattern of wildfires.

Some studies have linked wildfires with vegetation amount in the savannah climate zones in West Africa. For instance, Devineau, Fournier & Nignan (2010) studied the relationship between wildfires, land cover and plant species in Burkina Faso and concluded that areas that have high amount of foliage are more susceptible to fire outbreaks. However, areas with land use such as residential and commercial are less likely to be burn, because they are protected to prevent damage properties, highlighting human influences on wildfire occurrence or non-occurrence. Kugbe et al. (2012) studied the annual seasonal burnt area in the savannah region of Ghana and realized there was a similar, distinct inter-annual burnt area which coincides with the dry seasons in the northern region of Ghana.

Studying the relationship between wildfire and climate in Ghana is challenging. There is an insufficient amount of high resolution data for both climate variables and fire data. Studies that have been done use data that are relatively coarse so the relationship between the two is often unclear.

Some studies have linked wildfires to climate and meteorological (weather) variables in current climatic conditions. For instance, in a study of the state of severe temperatures and wildland fire in Spain, Cardil, Eastaugh & Molina (2015) discovered that high temperatures played a significant role in number of fires in Spain. This was the case in areas which were high in the amount of winds. Winds serve as catalysts which can increase the extent that fire will burn and the direction in which it burns. By implication therefore, even in lower temperatures with dry fuel load, fire ignition can still be possible even though the speed of burning may be slower. Other studies concur with this assertion. Flannigan & Wotton (2001) concluded in their study weather and climate are important determinants of wildfires. The climate determines the extent of foliage in an area and the weather determines whether temperatures are high or if it is windy etc. Consequently, an interaction between these two – climate and weather - strongly influence the risk of fire outbreaks and the extent the fire burns. Severe temperatures also result in heatwaves which have the potential of triggering large scale wildfires (Trigo et al. 2006).

On days when temperatures are high, there is low moisture content in foliage - fuel for wildfires - (Westerling et al 2006) implying on such days the likelihood of fire ignition is more imminent and fire response could be severe and unpredictable. Consequently, wildfires can spread faster and may be difficult to put off (Molina et al. 2010). Wildfires tend to be concentrated in the dry season in areas with mainly two seasons (in the tropical areas).

There is also a relationship between wildfire risks and the amount of rainfall in an area. For fires to occur, there should be sufficient fuel for the fire to consume (Hargrove et al. 2000 cited in Fannigan et al. 2009). This means there has to be sufficient amount of rainfall during the rainy season to allow vegetation to grow in abundance (Meyn et al. 2007). Rainfall also determines the extent to which fire can spread in an area. Wet fuel loads do not spread too quickly as compared to drier fuel loads. The dryness depends on whether there was some precipitation just before or during an ignition (Flannigan et al. 2005). In savannah regions of West Africa where there is a long dry season and high temperatures, spread of wildfires will be relatively faster than areas with moister fuel loads because the foliage does not completely dry out, especially in areas with tropical rainforests and deciduous forests.

Despite most models assuming close relationships between fire and climate, Archibald et al. (2010) present a contrasting view point. They contend that the assumptions supporting these models must be re-examined in areas such as the African savannah, where the "human impact on fire regimes is substantial, and acts to limit the responsiveness of fires to climatic events".

Therefore, even though wildfires are determined by climate and weather variables, there are non-climate influences to the ignition and spread of fire such as human interaction with the environment (Bleken, Mysterud and Mysterud 1997). Humans use fires for various economic activities, a basis for the conclusion by Pyne et al. (1996) that "fire problems are socially constructed problems" (cited in Westerling et al. 2006). Fire is commonly used for agricultural purposes, especially in the tropical areas. There is always a high potential that the fire may stray into the wild and destroy larger areas. Most wildfires are intentional, but due to poor control, they spread to areas that were not intended for burning. Wildfires are usually set for social and economic reasons, including forest management, animal grazing and crop cultivation and hunting among other (Bowman et al. 2011), especially in the sub-Saharan Africa.

Even though human activities can cause ignitions, they are also capable of reducing the amount of wildfires occurring in an area. Fire suppression policies and firefighting can reduce the amount and spread of wildfires. In Burkina Faso for instance, strict laws and regulations have been put in place in some rural areas to guard against cutting of trees and wildfires (Kugbe et al. 2012). It remains a challenge though for the burning to be completely eliminated.

The objective of this study is to assess the relationship between wildfires in Ghana and climate variables. Specifically, I will correlate average monthly precipitation and mean monthly temperature values for the driest months in the country, (November 2000 to March 2010), with MODIS Climate Modelling Grid (CMG) Active Fire Products. The study will also investigate the pattern of fire occurrence in terms of the north-south direction and its relationship with the seasonal movement of the ITCZ in the country. The ITCZ is the major natural determinant of climate and weather in Ghana. The hypothesis of this study is that there is no relationship between mean monthly temperature, average monthly precipitation and wildfires in Ghana.

Methods

Study area

The study covered the entire Ghana. Ghana is located on the geographical coordinates 8°N and 2°W, covering a total area of 239,460 km^2 (CIA World Factbook). The northern part of the country is mostly hot and dry for most parts of the year and the vegetation in the area is mostly savannah. The vegetation is influenced by precipitation/rainfall, lithology and the human activities (Lane 1962). The climate in the area gives it two distinct seasons: rainy season and dry season (harmattan).

The dry season lasts for five to six months (usually November to April), and the rainy season lasts for six to seven (May to October), with the severity of the harmattan increasing from north to south, in line with the movement of the Intertropical Convergence Zone (ITCZ) (figure 1a), which influences the pattern of rainfall in the country. Rainfall reliability is low and large digressions from monthly and annual averages are common (Owusu & Waylen 2009).

The southern part of Ghana (the deciduous, moist evergreen and wet evergreen forests) (figure 1b) experience two rainy seasons which match the northern and southern movements of the ITCZ across the region. The major rainy season occurs from March to July (with a peak in May- June), and a minor rainy season occurs in September to November, interspersed by a relatively short dry season in August and September, but rainfall occurs all year round (McSweeney et al. 2010). The southwest part of Ghana (wet evergreen,) is especially hot and moist but the southeast (coastal savannah zone) is relatively drier (Owusu & Waylen 2009).

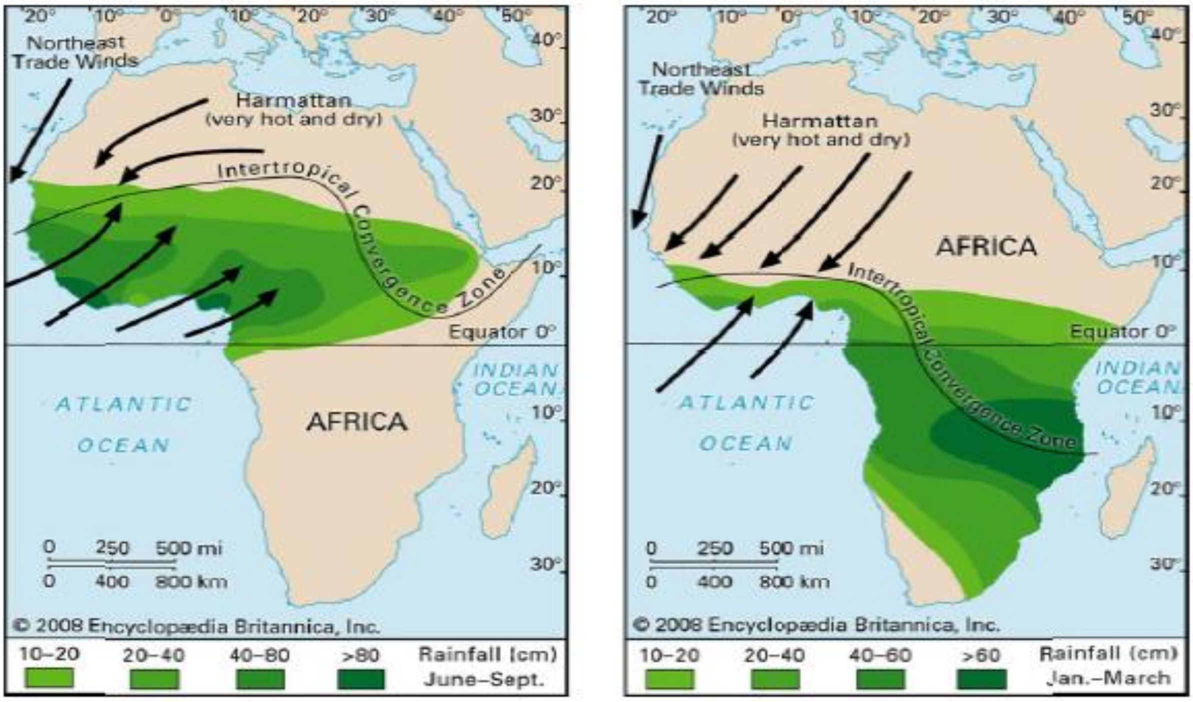

Figure 1a: North – south movement of the ITCZ in SSA, including Ghana. This results in dry and wet seasons in Ghana. (Source: Encyclopaedia Britannica Online)

Figure 1b is the vegetation map of Ghana. The type of vegetation is determined by the climate which is influenced by the movement of the ITCZ. More than half of the country consists mainly of savannah grasslands and forest transitions, the type of vegetation which are very prone to wildfires (Devineau, Fournier & Nignan 2010).

Figure 1b: The type of vegetation in Ghana. The pattern is influenced by the North – South movement of the ITCZ. (Source: http://exploringafrica.matrix.msu.edu/curriculum/unit-five/module-twenty-four/module-twenty-four-activity-one/).

Study design

The study was designed to examine how two climate variables – mean monthly temperature and average monthly precipitation/rainfall – influence wildfire patterns in Ghana. A correlation analysis and the maps of mean monthly temperatures and average monthly rainfall were used to measure the relationships and how they climate variables influence the patterns of wildfires. The dependent variable is the mean monthly fire for the study period and the independent variables are the mean monthly temperatures and the average monthly precipitation/rainfall.

Materials

MODIS Climate Modelling Grid (CMG) (MOD14CMH) Active Fire Products data were downloaded at a 0.25º by 0.025º resolution from an ftp server maintained by the University of Maryland, hosting the CMG and MCD14ML products (ftp://fuoco.geog.umd.edu). The data acquired was for six months of the harmattan season, starting from November to March for the period 2000 to 2010. These months are roughly the months when the harmattan season is across the entire country. The fire data covered the entire world.

To extract fire pixels which fall within the confines of Ghana, the raster map of each monthly data was opened in ArcMap (v10.3.1) and exported to .tif format using the 'Export Raster' tool. The contents of the world files in the .tif files were replaced with a new coordinate system. The new file were then re-opened with a new blank ArcMap document. A shapefile containing world map of countries was added to the new raster layer and the exact location of Ghana was identified. A 'selection by attribute' was done to select the boundaries of Ghana and mark out the pixels containing fire data from it.

The clip tool was used to extract the map of the country together with the fire pixels. The symbology of the pixels were changed in a manner that will indicate low – high number of fires in a color ramp. These maps will be used for comparing with the climate variables to investigate the pattern of wildfires in the country.

The climate data (namely mean monthly temperature and average monthly precipitation) for the study were obtained from the Climate Research Unit (CRU) of the University of East Anglia, United Kingdom, (1901-2014: CRU TS3.23 (land) 0.5°) (UEA CRU Jones and Harris 2008), downloaded from the KNMI Climate Explorer (http://climexp.knmi.nl). The November, 2000 to March 2010 data for both temperature and precipitation were extracted from this. TS (time-series) datasets are month-by-month variation in climate over the last 100 years, produced by the CRU. These are calculated on high-resolution (0.5º x 0.5º) grids, which are based on a database of mean monthly temperatures provided by more than 4,000 weather stations spread across the world (UEA CRU Jones & Harris 2008). They allow variability in climate to be observed, and include variables such as cloud cover, daily minimum and maximum temperature ranges, frost day frequency, precipitation, daily mean temperature, monthly average daily maximum temperature, potential evapo-transpiration and number of wet days. They are thus useful for studies such as this.

Procedure

To establish the relationship between MODIS fire data and climate, a correlation analyses be conducted between the mean monthly temperature of the country between November 2000 and March 2010 and the average monthly fire occurrence, and correlation between the average monthly precipitation and the average monthly fire occurrence calculated from the fire pixels for the same time period.

To investigate the pattern between the average monthly precipitation, mean monthly temperature and fire occurrence, maps will be plotted (using the November 2000 to March 2010 data) of the average monthly temperature and the mean monthly precipitation using the Grid Analysis and Display System (GrADS v2.1.a3, which is used online with the KNMI Climate Explorer), and the fire pixels for the same period as the climate variables, clipped out of the global fire data using the Clip raster tool in ArcMap and the same color ramp (indicating low - high) is applied to make them uniform.

Results

Figure 2a and figure 2b show observed mean monthly temperatures and average monthly precipitation respectively, between November 2000 and March 2010. Note that the month with the highest average monthly rainfall of the five months is November but the month with the highest mean monthly temperature during the period is March. Both graphs trend with the passage of the ITCZ (southwest monsoon winds) and the northeast trade winds which result in the wet and dry seasons respectively. The dry season starts in November when the ITCZ begins it southwards retreat and is replaced by the northeast trade winds (harmattan). Also, in the five months period, November has the highest amount of rainfall for the time period under study whereas the month with the highest mean temperature varies between the months of February and March.

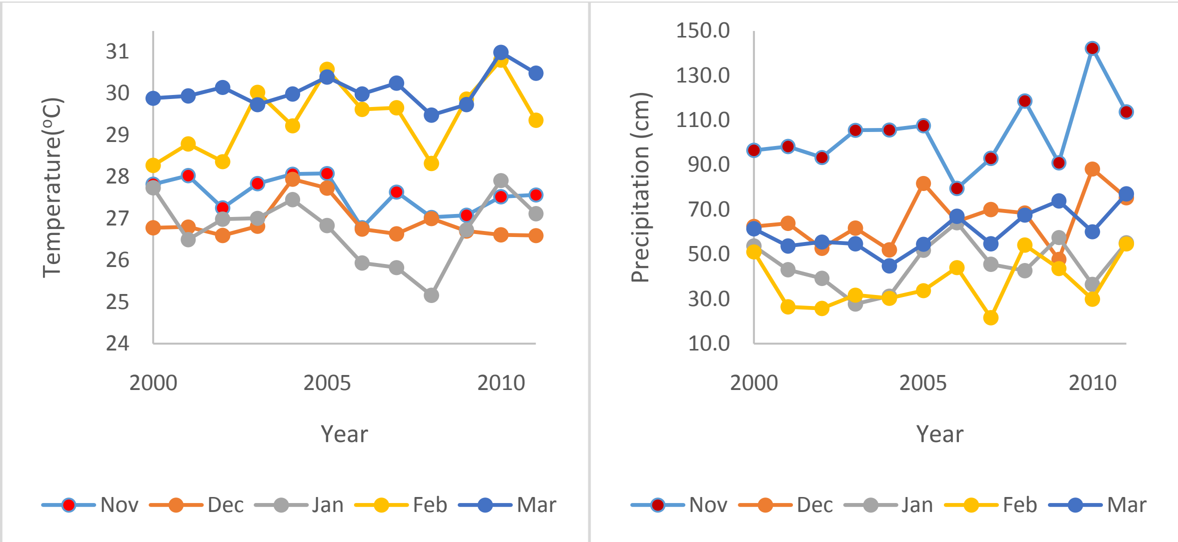

Figure 2. (a) Indicates the mean monthly temperature. (b) Shows the average monthly precipitation for the period November 2000 to March 2010 in Ghana (UEA CRU Jones and Harris 2008).

Figure 2c shows the mean number of fire occurring in each of the months for the period November 2000 to March 2010. There is a slow start to the mean number of fires in November, a peak in December and steady decline to very limited number of fires in March. This is closely related to figures 2a and 2b because the number of fires coincide with the start of the dry season and increases as the rainfall amount diminishes and the temperatures begin to rise. On average, the month of November has more rainfall, indicating more moist grasses and foliage, which means lesser probability of ignition, hence the relatively lower number of wildfires for that month. December has more fires because the ITCZ would have retreated further south, resulting in more dryness.

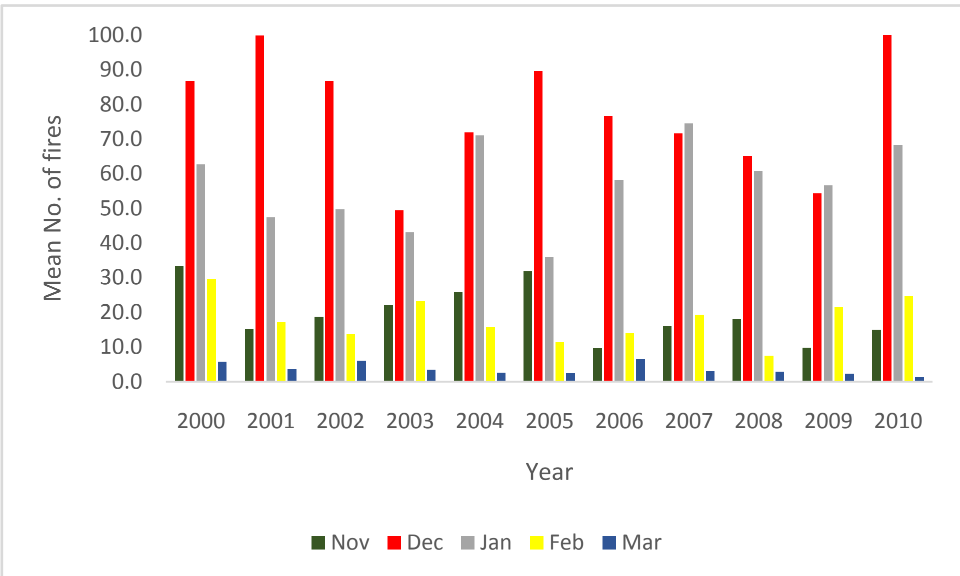

Figure 2c. Mean fire occurrence. There is a pattern for almost the years (except 2008 and 2010) in which the number of fires start low in November rise in December and decrease again afterwards. (Source: MODIS Active Fire Products).

Table 1a and b indicate the mean number of fires and the total number of fires in each pixel for each month in the study period. Both tables indicate the pattern of rising fires in November, peaking in December and a gradual reduction up to March. November is the beginning of the dry season and so wildfires start at about the same time and increases as the vegetation gets drier. By March most of the vegetation is burnt and so results in the low number of fires in the period.

Table 1a: Mean fire values for the period November 2000 to March 2010 in Ghana (MODIS Active Product).

Year	Nov	Dec	Jan	Feb	Mar
2000	33.4	86.6	62.6	29.5	5.6
2001	15.0	99.8	47.3	17.0	3.5
2002	18.6	86.6	49.6	13.5	6.0
2003	21.9	49.3	43.0	23.1	3.3
2004	25.7	71.8	70.9	15.7	2.4
2005	31.8	89.5	35.9	11.3	2.4
2006	9.5	76.5	58.1	13.9	6.4
2007	15.9	71.6	74.4	19.1	2.9
2008	18.0	65.0	60.8	7.3	2.9
2009	9.6	54.3	56.5	21.4	2.1
2010	14.9	104.8	68.3	24.5	1.3

Table 1b: Total number of fires in each pixel by month on the MODIS Active Fire Products (November 2000 to March 2010)

Year	Nov	Dec	Jan	Feb	Mar
2000	2738	7101	5132	2418	462
2001	1234	7682	3875	1398	285
2002	1524	7101	4066	1106	492
2003	1796	4041	3523	1895	274
2004	2107	5889	5811	1287	199
2005	2610	7343	2940	929	197
2006	782	6275	4763	1138	522
2007	1303	5870	6103	1569	241
2008	1476	5328	4985	602	234
2009	791	4449	4632	1754	176
2010	1225	8592	5598	2010	106

Table 2a indicates the coefficients (r) for the correlation between mean monthly temperatures, average monthly precipitation and MODIS Active Fire Products and table 2b represents the correlation between mean monthly temperature and average monthly precipitation. It can be seen that there is no meaningful correlation between the climate variables and the fire data. This is probably due the variations in both the vegetation types and the variations in climate variables between the northern and middle belts and the southern zone. The northern part of the country is mostly dry and largely savannah vegetation (which are more prone to wildfires) and the southern parts are deciduous, moist evergreen and wet evergreen forest (which are less prone to wildfires).

Table 2a. Correlation coefficients (r) of MODIS Active Fire Products and climate variables.

	Mean monthly temperature	Average month precipitation
November	0.69	0.15
December	-0.53	0.54
January	-0.24	-0.09
February	-0.32	-0.03
March	-0.35	0.10

Table 2b. Correlation coefficients (r) of mean monthly temperatures and average monthly precipitation.

Month	Correlation coefficient
November	0.22
December	-0.30
January	-0.34
February	0.30
March	0.34

Figure 3 indicates the month-by-month correlation between mean monthly temperatures and mean number if fires. Figure 4a shows the month-by-month relationship between average monthly precipitation and mean number of fires for the corresponding months and figure 4b shows the relationship between mean monthly temperatures (°C) and average monthly precipitation from November 2000 to March 2010. The scatter plots and the trend lines in both cases highlight that there is no significant relationship between the individual monthly climate variables and the MODIS Active Fire Products used.

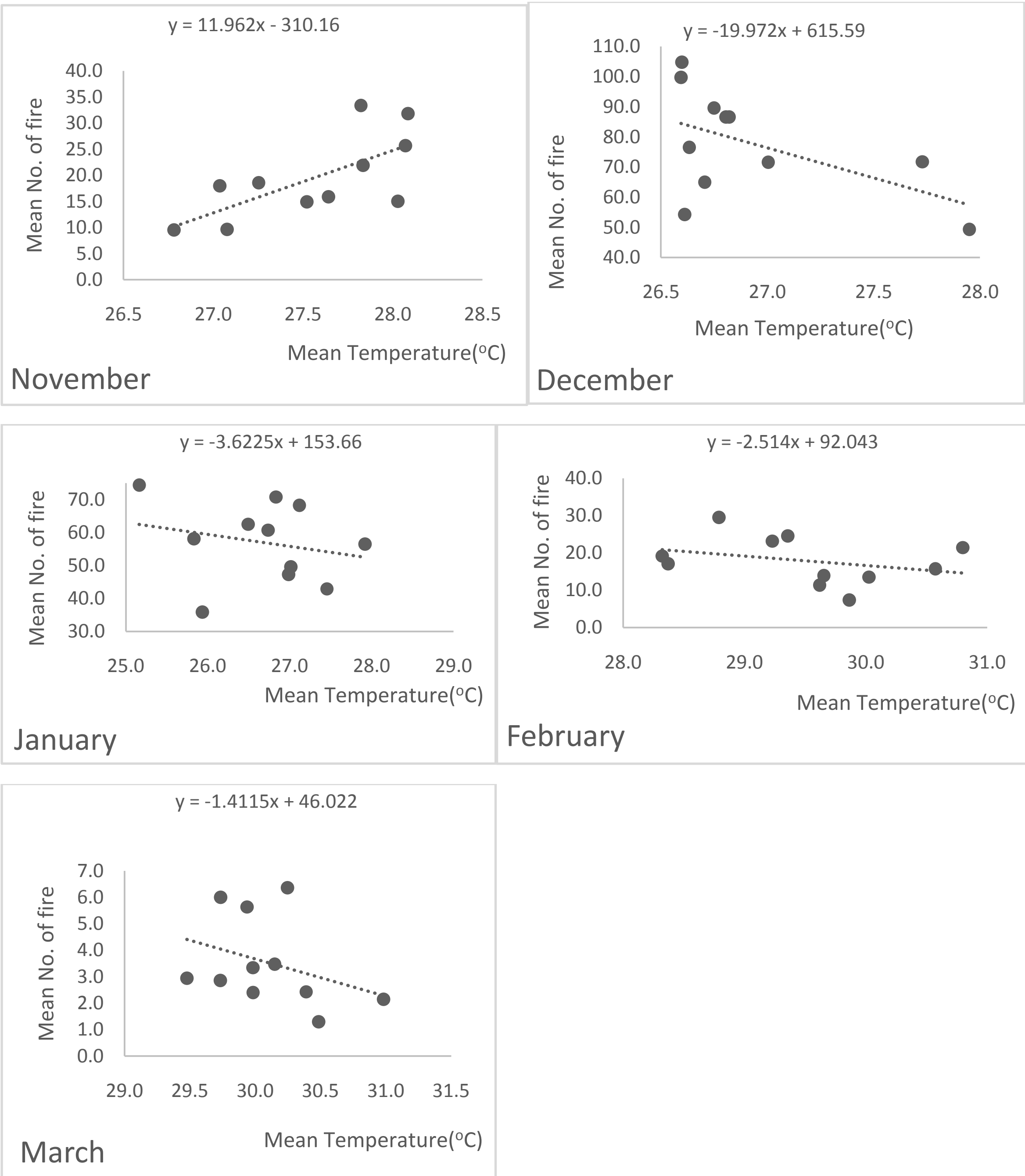

Figure 3. Scatter plots indicating the relationship between mean number of fires and mean monthly temperatures for November 2000 to March 2010.

The nature of the dots and the trend lines clearly indicate that there was not significant relationship between the individual mean monthly temperatures and the mean number of fires for the period.

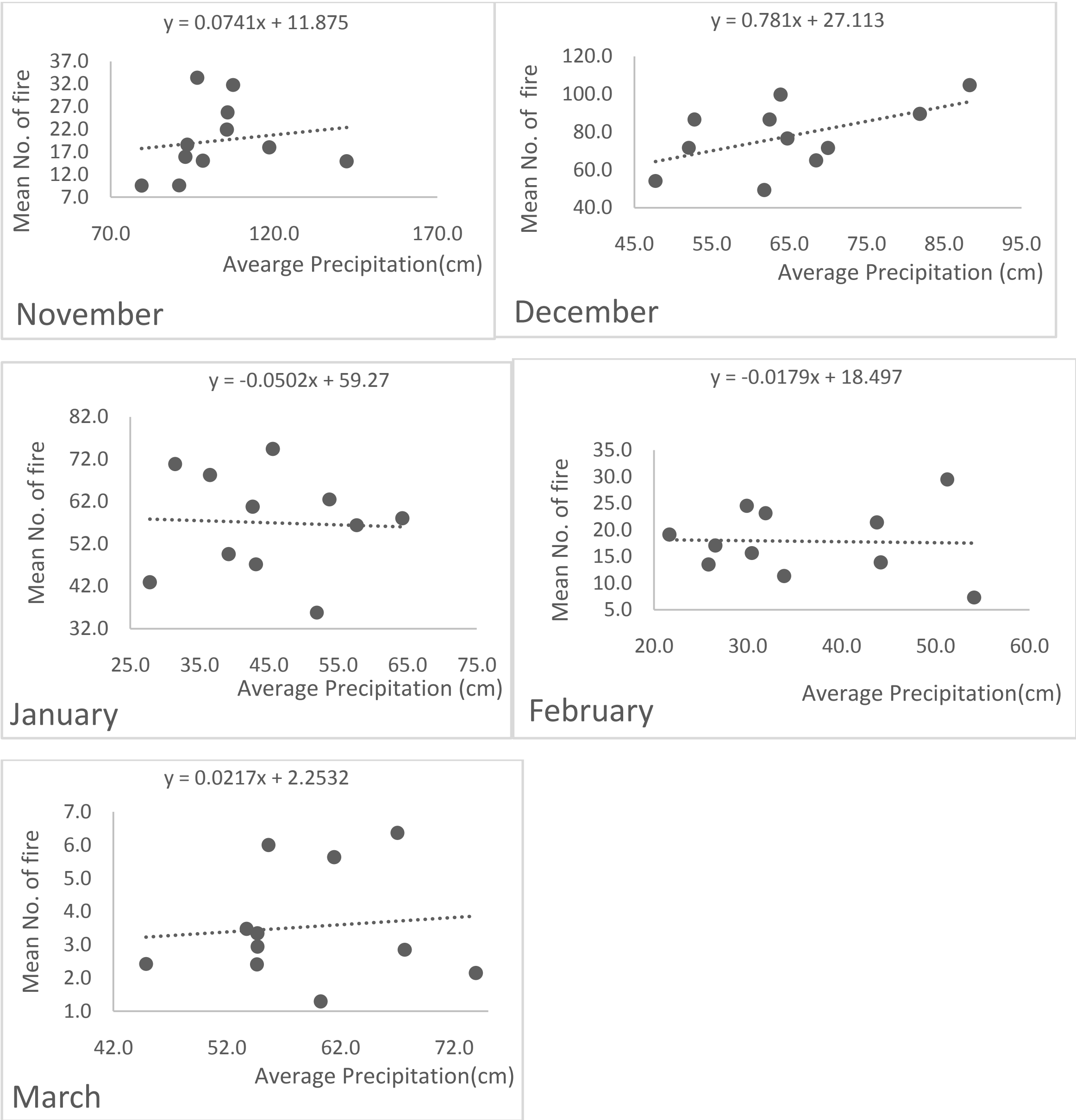

Figure 4a: the relationships between mean number of fires and average month precipitation for November 2000 to March 2010.

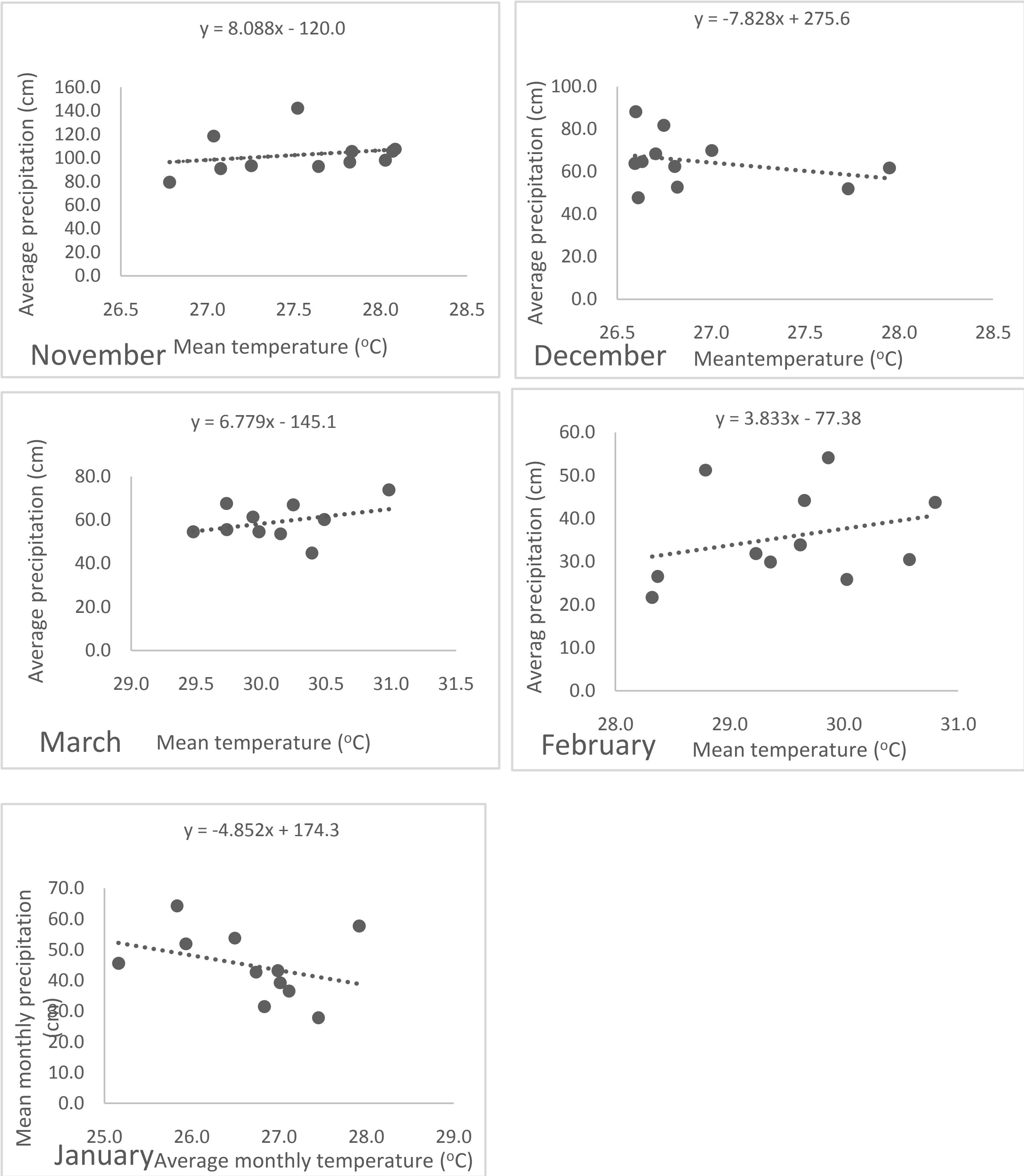

Figure 4b: the relationships between mean monthly temperature (°C) and average monthly precipitation for November 2000 to March 2010.

Figure 5 shows the pattern of fires from the beginning of the dry season in November to March when majority of dry fuel load would have been burnt. The number of pixels indicating fire in the month of November are limited mainly to the north-western corner of the map. This pattern is also visible in table 1b (where the total number of fires in November is lower in and increases in December). The burnt area increases as seen in the maps in December and begins to decrease until in March, when there is a very limited number of fire pixels. There is a concentration of fire pixels in the northern part of the country and very few number of fire pixels in the southern part.

Figure 6 shows the observed mean monthly temperatures for the period November 2000 to March 2010, the same time period as the MODIS Active Fire Products. These maps also indicate, in general, decreasing mean monthly temperatures from the north to the south of the country. The northern and middle belts have higher mean monthly temperatures than the southern and coastal parts.

Figure 7 shows the pattern of observed average monthly precipitation for the same time period as both MODIS Active Fire Products and the mean monthly temperature data. Even though the period coincides with the dry season, it is apparent that some parts of the country, mainly the southern portions receive some amount of rainfall (coinciding with the southern passage of the ITCZ). The northern parts are drier than the south and the dryness reduces southwards, and this could also explain the lack of correlation between the individual monthly climate data and mean fire occurrence (shown on table 2).

Comparing the figures 5, 6 and 7 show that there is a close relationship between the pattern of wildfires and the movement of the ITCZ which gives rise to the pattern of the climate in the country. As one moves southwards of the country the number of fire pixels increase with the months. The northern and middle belts indicate there is more fire that there is in the southern and coastal belt. The southwestern corner of the country indicates that there is virtually no fire. The south-western corner has the highest amount of rainfall in the country and the ITCZ does not completely retreat from that portion of the country. Hence vegetation in that part of the country never completely dries out. In addition, the area has moist evergreen and wet evergreen vegetation types (figure 1b), resulting from the climatic. The vegetation in the area does not completely dry out in the short dry season and so reduces ignition possibility and escalation of wildfires.

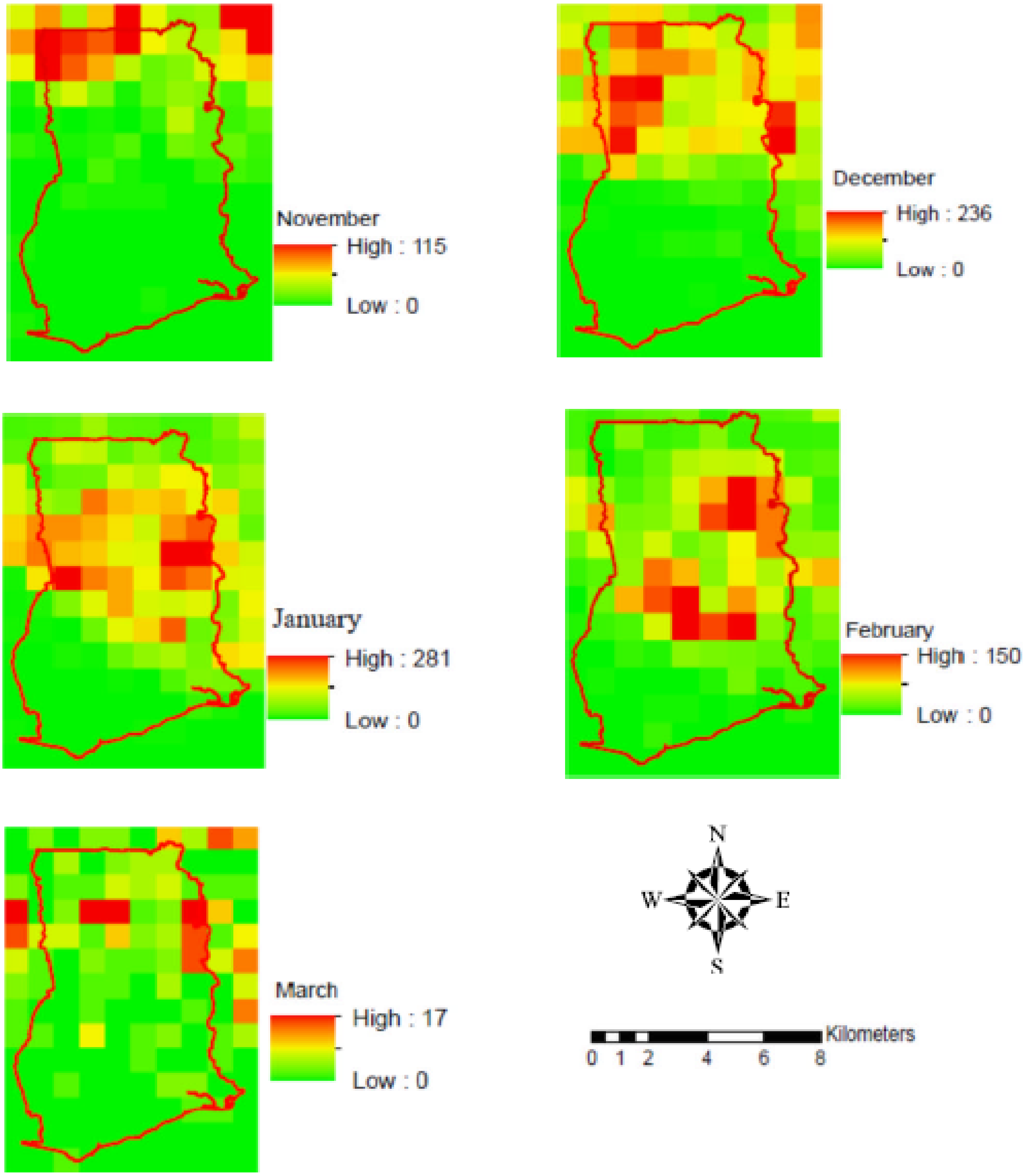

Figure 5: Pattern of fire occurrence in Ghana for the period November to March (2000 – 2010) (MODIS Active Fire Products)

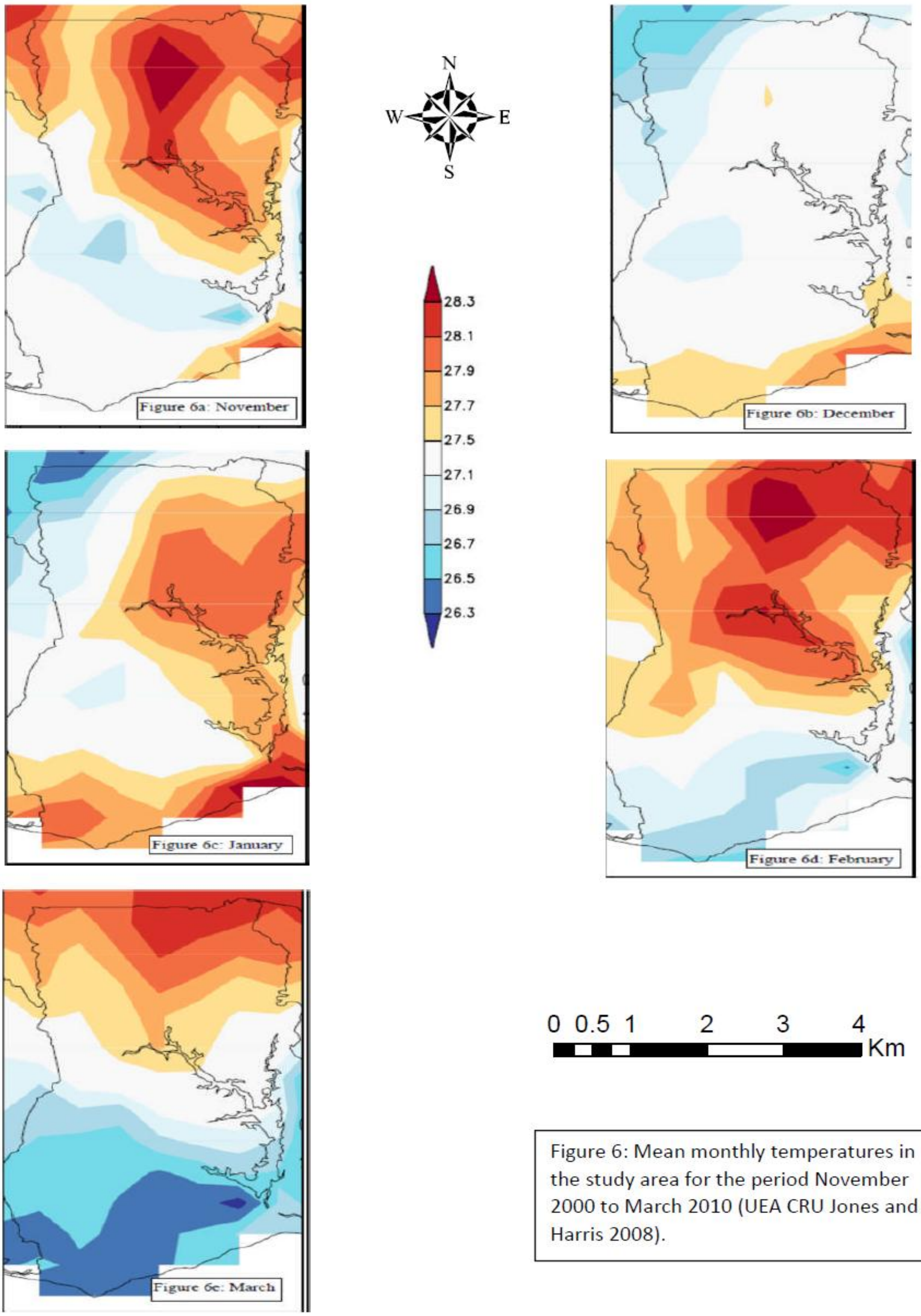

Figure 6: Mean monthly temperatures in the study area for the period November 2000 to March 2010 (UEA CRU Jones and Harris 2008).

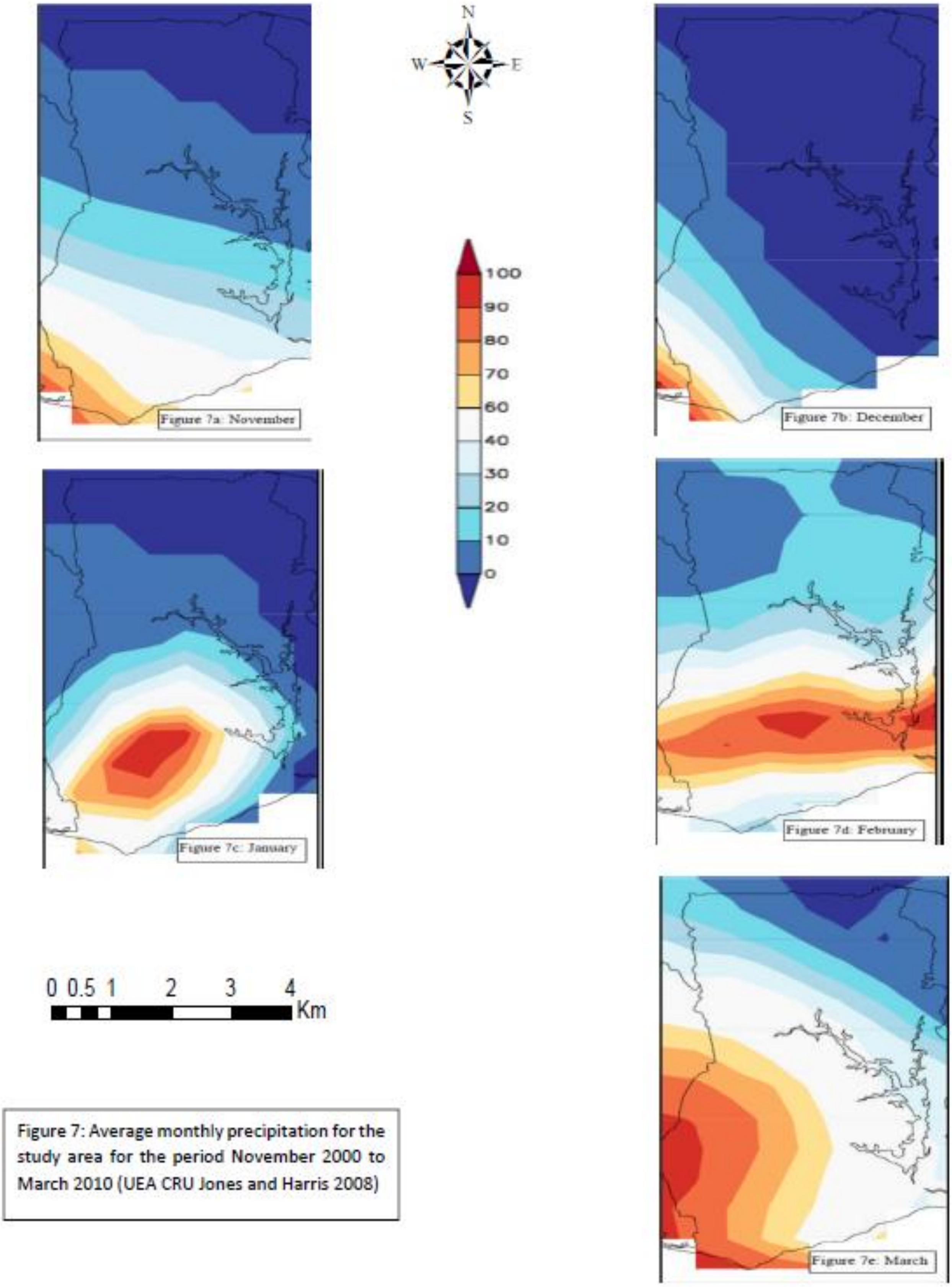

Figure 7: Average monthly precipitation for the study area for the period November 2000 to March 2010 (UEA CRU Jones and Harris 2008)

Discussion

This study aimed at establishing the relationship between MODIS CMG Active Fire Products and the climate variables mean monthly temperatures and average monthly precipitation over a five month period of the dry season, using data from November 2000 to March 2010, for both climate variables and fire. The climate variables were at a 0.5^{o} by 0.5^{o} resolution, whereas the fire data were at a 0.25^{o} by 0.25^{o} resolution. The study also aimed at investigating the patterns of wildfire occurrence and the pattern of climate in the country, using the north-south movement of the intertropical zone of convergence (ITCZ), which brings the southwest monsoon winds to the country.

It was discovered that there is no significant correlation between the individual mean monthly temperatures and the average monthly precipitation and the MODIS Active Fire Products. However, taken together (figures 5, 6 and 7) there is a strong relationship between the pattern of wildfire occurrence and the pattern of climate. As the mean monthly temperatures increase southwards, the average monthly precipitation decreases and the burnt area increases. This pattern coincides with the annual movement of the ITCZ which controls the wet and dry seasons in Ghana.

In general, SSA fire patterns are closely related to the southward movement of the ITCZ across the region (Swap et al. 2002 & N'Datchoh et al. 2015). This pattern is also observed in Ghana in this study. As the ITCZ starts to retreat southwards in November (figure 5), the extent of wildfires are very limited to just portions of the area in north western corner of the November map. The extent of burnt areas and total number of fires per pixel in a month (table 1b) are also very small in November compared to that of the month of December. As the ITCZ retreats in the subsequent months, the burnt areas extend southwards because the area becomes drier due to lack of rains and the influence of the dry northeast trades (harmattan winds). In February, the burnt area extends to almost the middle of the country (the transition zone), because the ITCZ has retreated to the southwestern corner of the country. By March, fire pixels are limited to only few areas (figure 5: comparing the month of March to December). Kugbe et al. (2012) also observed this reduction in the number of fires in March in Ghana and attributed it to a reduction in the amount of fuel load available for burning (as observed in figure 5). By March almost all dry foliage would have been exhausted and that accounts for the limited number of fire pixels in that month.

The study reveals the seasonality of wildfire occurrence in Ghana. This seasonality is influenced by the climate of the various areas in the country. Areas with prolonged dry seasons have high number of fires than areas with relatively shorter dry seasons. The savannah and transitional zones have relatively longer and more intense dry seasons than the deciduous, moist evergreen and wet evergreen areas (figure 1b). These are influenced by the climatic patterns. Le Page et al. (2010) observed such seasonality of wildfires on a global scale. They observed that Sub-Saharan African fires start in November, and move along the ITCZ. They reported that the pattern of fire goes with agricultural activities such as harvesting and preparation of lands for cultivation (which are triggers of wildfires in Ghana). Westerling et al. (2003) in a study of climate and wildfires in Western United States also concluded that wildfires were strongly seasonal. Heyerdahl, Brubaker & Agee (2002) further confirm the seasonality of wildfires based on climate influences. Studying the decadal occurrence of fires, they observed that large fires mostly occurred in the dry season and during El Nino years in interior Pacific Northwest of the United States of America.

Wildfires are more common in areas that have dry seasons because the vegetation dries up and provides fuel for combustion (Mbow, Nielsen & Rasmussen 2000). Thus, wildfire occurrence in Ghana vary from north to south, as is the case with the climate pattern in Ghana.

Devineua, Fournier & Nignan (2010) and Kugbe et al. (2012) have observed that the northern portion Ghana has a large savannah and grassland area comprising mainly of herbaceous and scrubland which are more amenable to wildfires. The tropical savannah ecosystems are produce very rapidly and are very flammable (Bowman et al. 2009) because they are composed of grasses, trees and scrubs, which provide sufficient fuel load for combustion.

Areas in Ghana which are dominated by vegetation with high amount of dry foliage in the dry season are more prone to wildfires than areas with relatively wet foliage. The type of vegetation in Ghana, as it is everywhere, is closely related to the climate. Comparing figure 1b and figure 5, it is obvious that the areas that contain the most fire pixels coincide with the savannah belt and transition zones in the country, whereas areas in the deciduous, moist evergreen and wet evergreen forests show fewer fire pixels. The climate in the savannah and transition zone have a prolonged dry season than areas with deciduous, moist evergreen and wet evergreen forests because of the combined influence of the retreat of the ITCZ and the advance of the harmattan winds from the Sahara Desert. On average, the area occupied by the deciduous, moist evergreen and wet evergreen forests is smaller than the area occupied by the savannah and transition belts. This mismatch is a probable cause of the lack of correlation between the individual monthly climate variables and the fire data. Archibald et al. (2010) in a study of Southern African fire regimes realized that areas with vegetation types that are dominated by a grass-layer (savannah, grassland and forest transitions) burnt more extensively than areas characterized by rainforest and semi-deciduous forest. The savannah zones of SSA are very prone to wildfires (Giglio et al. 2010) due to agricultural activities such as slash-and-burn, nomadism and hunting (Archibald et al 2010).

Conclusion

From the results above using our methodology, it is clear that wildfires in Ghana are influenced largely by climate because the number of fires follow the pattern of the movement of the ITCZ, the major phenomenon influencing weather and climate in Ghana, even though there were no correlation between individual monthly climate variables and mean monthly fire occurrence.

It also confirms the results by other studies which conclude that the pattern of wildfire occurrence and the extent of burnt areas in savannahs are influenced by the movement of the ITCZ. Further, the study observed the link between the vegetation of an area and its climate which determines its susceptibility to wildfires. By implication the vegetation type, which is determined by the climate, plays a significant role in determining the amount and type of fuel load needed for ignition.

I suggest that further studies should be on establishing the relationship between fire and climate variables in various ecological zones in Ghana rather than looking at the entire country as a whole, because the differences in vegetation masks the full effect of correlation between monthly climate variables and bushfires.

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