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Determining Rainfall Onset and Retreat Dates in Nigeria

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ABSTRACT This study assessed the relative efficiency of the use of rainfall amount and rainy days in the determination of rainfall onset and retreat dates in Nigeria between 1961 and 2000. Daily rainfall data were sourced from the archives of the Nigerian Meteorological Services, Oshodi Lagos. The specific locations where data were collected include: Ibadan, Ilorin, Kaduna and Kano. The method of percentage cumulative mean rainfall values was employed in the determination of the rainfall onset and retreat dates.The results obtained clearly showed that both the use of rainfall amount and rainy days are equally effective in the determination of the mean rainfall onset and retreat dates in Nigeria. With regards to the rainfall onset and retreat dates of the individual years however, the method based on the rainy days is more efficient than that based on the rainfall amount, as the formal yielded a much more realistic dates than the latter. It is thus recommended that studies investigating rainfall onset and retreat dates series of the individual years should be based on rainy days rather than rainfall amount.

INTRODUCTION

Several methods of determining the onset and retreat of the rains in West Africa in general and Nigeria in particular, have been formulated. The various methods can be classified into five main categories, namely: (a) Intertropical Discontinuity (ITD) – rainfall model, (e.g. Ilesanmi, 1972a; Kowal and Knabe, 1972), (b) rainfall-evapotranspiration relation model (Cocheme and Franquin, 1967; Benoit, 1977), (c) percentage cumulative mean rainfall model – based on rainfall data alone (Ilesanmi, 1972b; Adejuwon et al., 1990), (d) wind shear model (Omotosho, 1990) and (e) the theta – E technique (Omotosho et al., 2002). Among these existing techniques of estimating rainfall onset and retreat dates however, the use of the percentage cumulative mean rainfall appears to be one of the most frequently used methods (e.g. Ilesanmi, 1972b; Olaniran, 1983; Adejuwon, 1988; Adejuwon et al., 1990; Bello, 1995). This method is found widely in use because, as observed by Olaniran (1983), the method gave mean onset of the rains that did not differ significantly from the mean start of the growing season for all the locations in the country. It was also noted that at any time and at any location where the method appear to be less accurate in the determination of the seasonal parameters under consideration, the dry spells involved are very short (mostly less than 5 days), the frequency of occurrences is very low and locations where such occurs are very few (Olaniran, 1983). Also, the overall advantage of this method is that it uses the rainfall data, which is a direct estimate rather than the use of some rainfall-associated factors to make inferences. Also, as noted by Olaniran (1983), rainfall data is one of the most readily available data in all the climatic station in the country.

The main problem is that the various attempts in the literature, using the method of percentage cumulative mean rainfall to estimate rainfall onset and retreat dates in Nigeria have been based on the use of rainfall amount alone. Whereas, rainfall frequency (in terms of rainy days) is another component of rainfall, which in fact, appear to be relatively more important to agriculturists than the amount. In fact, the parameter of rainy days already has some rainfall amount connotation in it, as a day can only be defined as rainy, using certain threshold. The method of percentage cumulative mean rainfall determines rainfall onset and retreat dates, using certain proportion of the annual rainfall totals (the method is fully described under the methodology section). Both the use of rainfall amount and rainy days may produce extremely similar mean onset and retreat dates, as the mean proportion of the two parameters may approximate each other on the long run. However, there may be need to generate the rainfall onset and retreat dates of individual years, using the mean proportion of the annual total designated as onset and retreat periods. Such rainfall onset and retreat dates of individual years may be necessary to generate rainfall onset and retreat dates time series, for the purpose of prediction, or for verifying the rainfall onset and retreat dates forecasts of individual years. The

problem that may likely confront the method based on the rainfall amount in this regard is that, one or two but large isolated showers at the beginning or end of the year may constitute the specified rainfall onset/retreat proportions. This would generate unrealistic rainfall onset and retreat periods. Whereas, rainy days frequency is only high when the rainfall has truly commenced and low only when the rainfall has retreated in earnest.

Therefore, this study investigates the relative efficiency of the use of rainfall amount and rainy days in the determination of rainfall onset and retreat dates in Nigeria, using the percentage cumulative mean rainfall. The specific objectives include:

(a) determining the mean rainfall onset and retreat dates, using the percentage cumulative mean rainfall amount;
(b) determining the mean rainfall onset and retreat dates, using the percentage cumulative mean rainy days;
(c) determining for the individual years, the relative rainfall onset and retreat dates, using the percentage cumulative mean rainfall amount; and
(d) determining for the individual years, the relative rainfall onset and retreat dates, using the percentage cumulative mean rainy days.

STUDY AREA

The study area, Nigeria (approximately latitudes 4^0 – 14^0N north of the equator and Longitudes 3^0 - 15^0 east of the Greenwich meridian), lies at the southeastern edge of the West African region Fig. 1. The country is about 923,300 km^2.

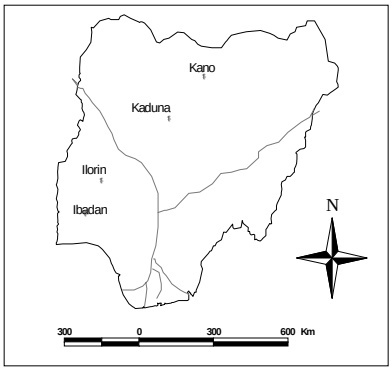

Fig.1. Map of Nigeria, showing the selected rainfall stations.

The climate of Nigeria is more varied than those of any other country in West Africa. This is due to the fact that the distance from the south to the north of the country is very great (1, 100km) and thus covers many (virtually, all) of the climatic belts of West Africa (Iloeje, 1981). The climate is dominated by the influence of three main wind currents. These wind currents include the tropical maritime (mT) air mass, the tropical continental (cT) air mass and the equatorial easterlies (Ojo, 1977). The first air mass originates from the southern high-pressure belt located off the Namibian coast, and in its path picks up moisture from over the Atlantic Ocean and is thus wet. The second air mass (cT) originates from the high-pressure belt north of the Tropic of Cancer. This latter air mass picks up little moisture along its path and is thus dry. These first two air masses (mT and cT) meet along a slanting surface called the Intertropical Discontinuity (ITD). The third air mass (equatorial easterlies) is a rather erratic cool air mass, which comes from the east and flow in the upper atmosphere along ITD. This air mass dives down occasionally to actively undercut the mT or cT air mass and give rise to line squalls or dust devils (Iloeje, 1981). Rainfall commences at the beginning of the rainy season from the coast (in the south), spreads through the middle belt, to eventually reach the northern part very much later. The converse of the situation also holds for the rainfall retreat period (Ojo, 1977; Iloeje, 1981).

The specific locations of the country selected for the study include: Ibadan, Ilorin, Kaduna and Kano. These locations which are found along a trajectory of southwesterlies are at great latitudinal distances from each other so that rainfall onset and retreat dates would clearly reflect the latitudinal order of the locations.

STUDY METHODOLOGY

Data Collection

The data required for this study is daily rainfall. The data were sourced from the archives of the Nigerian Meteorological Services, Oshodi, Lagos. The data were collected for four synoptic meteorological stations in the country – Ibadan, Ilorin, Kaduna and Kano, variously between 1961 and 2000. The mean rainfall onset dates were determined, using the daily rainfall data

between 1961 and 2000, while those of the individual years were determined using the daily rainfall data between 1971 and 2000.

Percentage Mean Cumulative Rainfall

The proponents of the method of percentage cumulative mean rainfall for determining rainfall onset and reatreat dates include Ilesanmi (1972a, b), Adejuwon (1988) and Adejuwon et al. (1990). The first essential step of the method is to derive the mean annual rainfall that occurs at each 5-day interval of the year. This is followed by computing the percentage of the mean annual rainfall that occurs at each 5-day interval of the year. Next is cumulating the percentages of the 5-day periods. Finally, when the cumulative percentage is plotted against time through the year, the first point of maximum positive curvature of the graph corresponds to the time of rainfall onset, while the last point of maximum negative curvature corresponds to the rainfall retreat. These points of maximum curvatures corresponding to the onset and retreat of rainfall are respectively 7-8 percent and over 90 percent of the annual rainfall. In this study, the graphical method is used to determine the mean proportion, and then the mean proportion is used to estimate for each year, the rainfall onset and retreat dates.

Rainy Days

There is need to define the threshold value of rainfall amount required for a day to be counted as rainy. Two thresholds are usually employed by the Nigerian Meteorological Services Oshodi, Lagos, - 0.3mm or 1mm. However, several thresholds have been tried by Garbutt et al. (1981) and 0.85mm was found appropriate for Agricultural purposes in West Africa. Therefore, a threshold value of 0.85mm is employed in this study. This implies that, all values below this threshold value is assumed to be zero.

RESULTS

Figures 2, 3, 4 and 5 show the cumulative percentage of both the mean annual rainfall amount and rainy days that occur at each 5-day periods between 1961 and 2000, respectively in Ibadan, Ilorin, Kaduna and Kano. Both the cumulative percentage of the mean annual rainfall amount and rainy days that occur at each

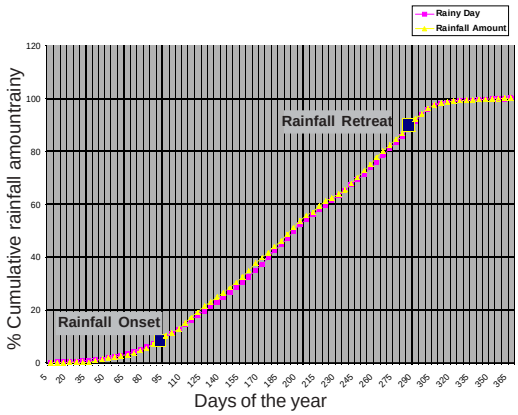

Fig. 2. Mean rainfall onset and retreat dates in Ibadan (1961-2000).

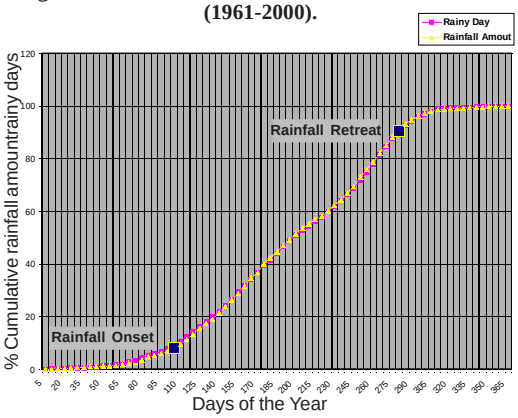

Fig. 3. Mean rainfall onset and retreat dates in Ibadan (1961-2000).

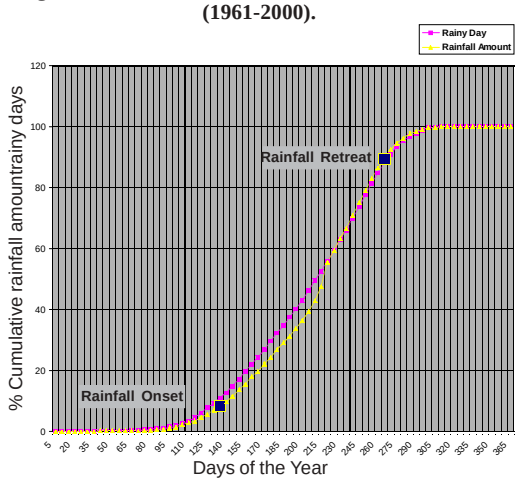

Fig. 4. Mean rainfall onset and retreat dates in Kaduna (1961-2000).

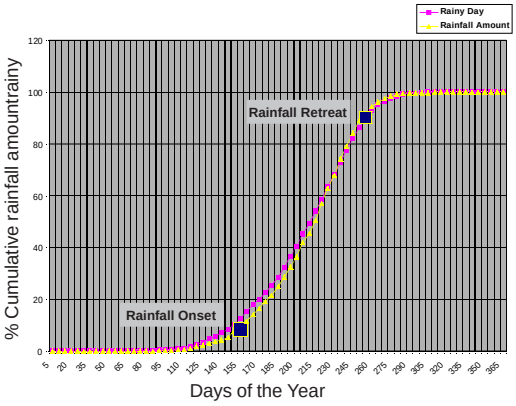

Fig. 5. Mean rainfall onset and retreat dates in Kano (1961-2000)

5-day periods were plotted concurrently on the same figure for each station. The results of the graphs obtained show that the two series (using rainfall amount and rainy days) approximate each other totally in terms of configuration in all the stations. In most cases, the two graphs are observed to be directly on top of each other (merging to one), while in some other cases (at worst) they are juxtaposed. In other words, both methods of determining mean rainfall onset and retreat dates (i.e. using rainfall amount and rainy days) give the same mean rainfall onset and retreat periods in all the stations studied. The first point of maximum positive curvature of the graphs (corresponding to the time of rainfall onset) of Ibadan, Ilorin, Kaduna and Kano are respectively 31st March, 15th April, 15th May and 4th June. Although, both the methods of rainfall amount and rainy days converge to give the same mean dates of the rainfall onset and retreat dates, the respective cumulative percentage rainfall values at which the various dates were obtained are at variant. For instance, while the first point of maximum positive curvature of the graph, using rainfall amount method, had cumulative percentage rainfall value of 8% uniformly in all of the stations studied, those of rainy days method are 9%, 9%, 11% and 13% for Ibadan, Ilorin, Kaduna and Kano, respectively (See Tables 1, 2, 3 and 4). The last points of maximum negative curvature of the various graphs (corresponding to the time of rainfall retreat) are respectively 12th October, 7th October, 22nd September and 12th September. While their respective cumulative percentage rainfall values, using rainfall amount, is uniformly 90% in all of the stations studied, the rainy days method gives the cumulative percentage rainfall values of 89%, 90%, 88% and 90% respectively. For the details of these results see Tables 1, 2, 3 and 4.

Tables 5 and 6 show the rainfall onset and retreat dates obtained for the individual years between 1971 and 2000 in Ibadan, Ilorin, Kaduna and Kano, using rainfall amount. These results are also diagrammatically displayed in Figures 6 and 7. The results obtained clearly

Table 1: Percentage cumulative mean Annual rainfall amount/rainy days at each 5-day interval through the year in Ibadan (1961-2000)

Days of the year in pentads	*Percentage cummulative rainfall*	*Percentage cummulative rainy days*	*Days of the year in pentads*	*Percentage cummulative rainfall amount*	*Percentage cummulative rainy days*
5	0.04	0.11	190	48.52	47.10
10	0.05	0.14	195	51.29	49.65
15	0.10	0.17	200	53.68	52.18
20	0.16	0.31	205	55.66	54.25
25	0.24	0.58	210	57.11	55.93
30	0.31	0.69	215	59.44	57.98
35	0.35	0.74	220	61.17	59.73
40	0.80	0.98	225	62.37	61.54
45	1.20	1.33	230	63.85	63.22
50	1.81	1.86	235	65.31	65.08
55	2.08	2.26	240	67.64	67.37
60	2.54	2.66	245	70.14	69.23
65	2.92	3.30	250	72.57	71.23
70	3.74	4.13	255	74.91	73.60
75	4.82	4.96	260	77.75	75.92
80	5.49	5.92	265	80.03	78.42
85	7.13	7.20	270	82.25	80.97
90	8.35	8.51	275	84.33	83.41
95	10.11	9.84	280	86.68	85.85
100	11.22	10.99	285	89.85	88.59
105	12.82	12.48	290	92.34	91.19
110	15.15	14.53	295	94.20	93.74
115	17.15	16.10	300	96.10	95.87
120	19.12	18.05	305	97.44	97.23
125	21.39	19.49	310	98.21	98.11
130	23.08	21.35	315	98.63	98.64
135	24.78	22.98	320	98.96	98.85
140	26.39	24.68	325	99.08	99.04
145	28.60	26.68	330	99.25	99.20
150	30.34	28.38	335	99.36	99.39
155	32.53	30.29	340	99.52	99.48
160	34.67	32.47	345	99.72	99.64
165	37.52	35.02	350	99.99	99.83
170	39.68	37.20	355	100.00	99.86
175	41.65	39.84	360	100.05	99.95
180	43.94	42.23	365	100.08	100.04
185	46.10	44.60			

Table 2 : Percentage cumulative mean annual rainfall amount/rainy days at each 5-day interval through the year in Ilorin (1961-2000)

Days of the year in pentads	*Percentage cummulative rainfall*	*Percentage cummulative rainy days*	*Days of the year in pentads*	*Percentage cummulative rainfall amount*	*Percen tage cummulative rainy days*
5	0.13	0.10	190	47.09	46.55
10	0.13	0.14	195	49.04	48.84
15	0.23	0.24	200	51.61	50.86
20	0.26	0.34	205	53.67	52.76
25	0.57	0.50	210	55.26	54.48
30	0.68	0.54	215	56.92	56.32
35	0.72	0.60	220	58.08	57.82
40	1.00	0.76	225	60.03	59.78
45	1.07	0.88	230	62.12	61.89
50	1.29	1.18	235	64.41	64.06
55	1.40	1.46	240	66.92	66.32
60	1.57	1.82	245	69.40	68.82
65	1.82	2.10	250	72.90	71.92
70	2.33	2.80	255	75.77	74.69
75	2.93	3.50	260	78.57	77.82
80	3.44	4.46	265	82.14	81.41
85	4.60	5.22	270	85.08	84.66
90	5.22	5.92	275	88.13	87.76
95	6.03	6.76	280	90.41	90.38
100	6.68	7.82	285	93.34	92.58
105	8.14	9.20	290	94.69	94.20
110	9.54	10.74	295	96.33	95.92
115	11.42	12.42	300	97.29	97.04
120	13.39	14.29	305	98.05	98.06
125	15.57	16.16	310	98.46	98.70
130	17.39	17.96	315	98.93	99.04
135	19.06	19.74	320	99.07	99.22
140	21.35	21.91	325	99.13	99.26
145	23.89	24.26	330	99.15	99.36
150	26.32	26.70	335	99.27	99.46
155	28.86	29.44	340	99.55	99.64
160	31.60	31.82	345	99.58	99.68
165	34.39	34.35	350	99.85	99.84
170	36.74	36.91	355	99.88	99.88
175	40.04	39.35	360	99.90	99.94
180	42.40	41.52	365	100.06	99.98
185	44.72	43.99			

Table 3: Percentage cumulative mean annual rainfall amount/rainy days at each 5-day interval through the year in Kaduna (1961-2000)

Days of the year in pentads	*Percentage cummulative rainfall*	*Percentage cummulative rainy days*	*Days of the year in pentads*	*Percentage cummulative rainfall amount*	*Percen tage cummulative rainy days*
5	0	0.00	190	31.41	37.50
10	0	0.00	195	33.64	40.12
15	0	0.00	200	36.39	42.98
20	0	0.00	205	39.39	46.19
25	0.03	0.04	210	42.83	49.57
30	0.03	0.04	215	47.39	52.60
35	0.03	0.04	220	55.46	56.00
40	0.19	0.13	225	59.43	59.41
45	0.21	0.20	230	63.45	62.96
50	0.21	0.20	235	66.75	66.16
55	0.23	0.27	240	70.95	69.81
60	0.23	0.27	245	75.25	73.76
65	0.23	0.34	250	78.95	77.68
70	0.26	0.47	255	83.13	81.36
75	0.36	0.57	260	86.53	84.76
80	0.39	0.77	265	89.58	88.16
85	0.55	0.98	270	92.56	90.84
90	0.74	1.19	275	94.61	93.57
95	1.16	1.57	280	96.26	95.33
100	1.44	2.03	285	97.74	96.76
105	2.13	2.62	290	98.40	97.85
110	2.77	3.44	295	99.08	98.86
115	3.44	4.64	300	99.62	99.58
120	4.70	6.13	305	99.85	99.82
125	5.68	7.91	310	99.97	100.01
130	7.14	9.32	315	100	100.05
135	8.40	11.06	320	100	100.05
140	9.71	12.70	325	100	100.05
145	11.59	14.92	330	100	100.05
150	13.65	17.24	335	100	100.05
155	15.57	19.86	340	100	100.05
160	17.94	22.00	345	100	100.05
165	19.62	24.32	350	100	100.05
170	22.14	26.90	355	100	100.05
175	24.27	29.60	360	100	100.05
180	26.77	32.36	365	100	100.05
185	29.04	34.81			

show that there are a lot of inconsistencies in the rainfall onset and retreat dates of the various stations, using rainfall amount. For instance, it is unrealistic to say that rainfall commences in Ilorin earlier than Ibadan as estimated by the method for the years 1979, 1980, 1981, 1983, 1986, 1988 and 1989. Also, it is unrealistic to say that rainfall commences in Kano earlier than Kaduna as estimated by the method for the years 1972, 1984, 1991, and 1992. The method also gives unrealistic dates of rainfall retreat in all of the four stations studied. For instance, the method shows that rainfall retreats earlier in Kaduna than Kano in years 1971, 1976 and 1981. Also, the method shows that rainfall retreats earlier in Ibadan than Ilorin in years 1971, 1972, 1976, 1981, 1982, 1983, 1985, 1992 and 2000. A particularly funny case is year 1984 where the method gave rainfall retreat date of Ilorin that is earlier than even that of Kano. The rainfall retreat date of Ilorin for 1996 is also earlier than that of Kaduna and approximates that of Kano. Table 7 and 8 show the rainfall onset and retreat dates obtained for the individual

years between 1971and 2000 in Ibadan, Ilorin, Kaduna and Kano, using rainy days. These results are also diagrammatically displayed in Figures 8 and 9. The results obtained clearly show that this later method of determining rainfall onset and retreat dates is more realistic, as rainfall is observed to commence normall in all the years of observation from Ibadan, and spreads through Ilorin and Kaduna to reach Kano. So also, rainfall retreats consistently from Kano, through Kaduna and Ilorin, to reach Ibadan later.

Table 4: Percentage cumulative mean annual rainfall amount/rainy days at each 5-day interval through the year in Kano (1961-2000)

Days of the year in pentads	*Percentage cummulative rainfall amount*	*Percentage cummulative rainy days*	*Days of the year in pentads*	*Percentage cummulative rainfall amount*	*Percentage cummulative rainy days*
5	0	0.00	190	28.40	32.49
10	0	0.00	195	32.31	36.58
15	0	0.00	200	36.46	40.49
20	0	0.00	205	41.78	45.33
25	0	0.00	210	45.39	49.38
30	0	0.00	215	50.51	54.02
35	0	0.00	220	57.04	58.50
40	0.03	0.06	225	62.91	63.49
45	0.03	0.06	230	68.09	68.21
50	0.03	0.06	235	74.17	72.93
55	0.03	0.06	240	79.13	77.75
60	0.04	0.12	245	84.19	81.97
65	0.04	0.12	250	89.02	86.21
70	0.04	0.12	255	90.09	89.62
75	0.11	0.22	260	94.49	92.68
80	0.11	0.22	265	96.32	95.09
85	0.11	0.28	270	97.53	96.45
90	0.20	0.40	275	98.53	97.85
95	0.30	0.52	280	99.34	98.66
100	0.38	0.58	285	99.58	99.25
105	0.42	0.70	290	99.81	99.49
110	0.50	1.05	295	99.89	99.61
115	1.04	1.82	300	99.99	99.96
120	1.78	2.53	305	100.00	100.02
125	2.43	3.40	310	100.01	100.02
130	2.81	4.60	315	100.01	100.02
135	3.63	5.74	320	100.01	100.02
140	4.10	6.98	325	100.01	100.02
145	5.22	8.38	330	100.01	100.02
150	7.82	10.33	335	100.01	100.02
155	8.28	12.62	340	100.01	100.02
160	11.5	15.21	345	100.01	100.02
165	14.03	17.91	350	100.01	100.02
170	16.46	19.82	355	100.01	100.02
175	19.01	22.54	360	100.01	100.02
180	21.53	25.36	365	100.01	100.02
185	24.92	28.62			

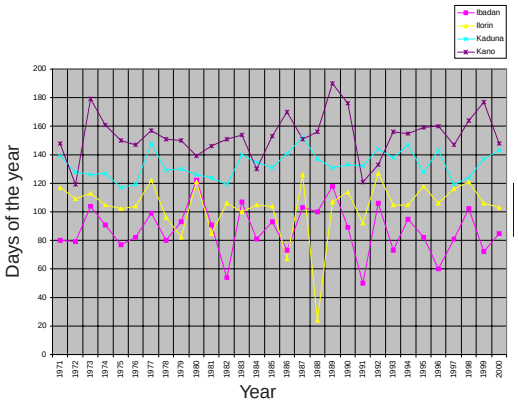

Fig. 6. Rainfall onset dates, using rainfall amount (1971-2000)

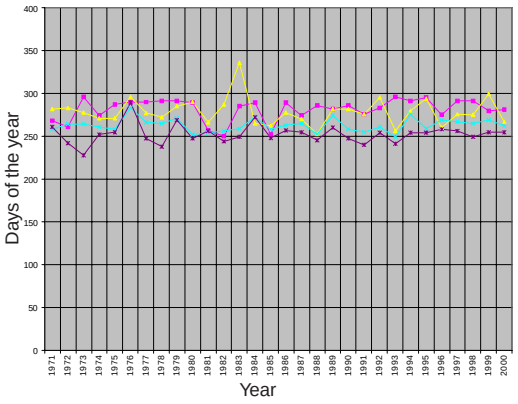

Fig. 7. Rainfall ratreat dates (in days of the year), using rainfall amount (1971-2000)

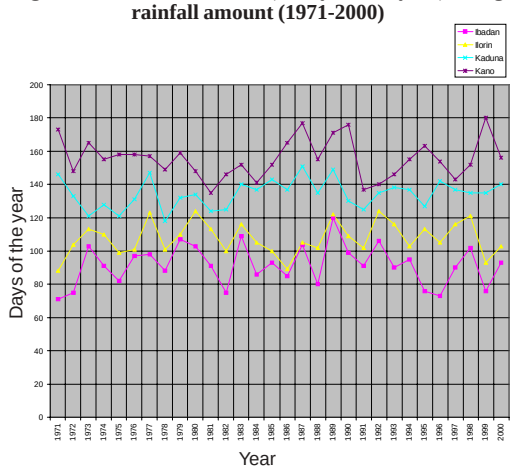

Fig. 8. Rainfall onset dates, using rainy days (1971-2000)

DISCUSSION

The study established that, between 1961 and

Table 5: Rainfall onset dates (in days of the year) using rainfall amount (1971-2000)

Year	*Ibadan*	*Ilorin*	*Kaduna*	*Kano*
1971	80	117	139	148
1972	79	109	128	119
1973	104	113	126	179
1974	91	105	127	161
1975	77	102	117	150
1976	82	104	119	147
1977	99	122	148	157
1978	80	96	129	151
1979	93	82	130	150
1980	122	121	126	139
1981	91	85	124	146
1982	54	106	119	151
1983	107	100	140	154
1984	81	105	135	130
1985	93	104	131	153
1986	73	67	141	170
1987	103	126	152	151
1988	100	24	137	156
1989	118	107	131	190
1990	89	114	133	176
1991	50	92	132	121
1992	106	127	144	133
1993	73	105	138	156
1994	95	105	147	155
1995	82	118	128	159
1996	60	106	143	160
1997	81	116	119	147
1998	102	121	124	164
1999	72	106	137	177
2000	85	103	143	148

Table 6: Rainfall retreat dates (in days of the year) using rainfall amount (1971-2000)

Year	*Ibadan*	*Ilorin*	*Kaduna*	*Kano*
1971	268	282	258	261
1972	261	283	264	242
1973	296	278	264	228
1974	274	271	261	252
1975	287	271	258	255
1976	290	296	283	289
1977	290	277	266	247
1978	291	272	265	238
1979	291	285	271	269
1980	289	290	252	247
1981	257	266	254	256
1982	250	287	256	244
1983	285	336	259	249
1984	289	265	272	272
1985	252	262	258	248
1986	289	278	263	257
1987	274	270	265	255
1988	286	253	253	245
1989	282	282	274	260
1990	286	282	258	247
1991	276	276	255	240
1992	283	295	261	254
1993	296	256	249	241
1994	291	280	276	254
1995	295	294	259	254
1996	275	260	269	258
1997	291	276	267	256
1998	291	275	265	249
1999	280	299	269	255
2000	281	267	262	255

2000, on the average, rainfall sets in at the beginning of the season from Ibadan and spread through Ilorin and Kaduna, to reach Kano. These results are in conformity with the established fact in the literature. It should be noted that the largest proportion of the moisture supplied into the atmosphere over West African hinterlands appear to emanate from the Atlantic Ocean. The moisture from the ocean is embedded in the southwesterly flowing wind, which advances from the Gulf of Guinea South of Ibadan, to spread from the station to Ilorin, Kaduna and eventually Kano (see for example, Ojo, 1977; Adedokun, 1978; Adefolalu, 1999). The converse of this situation holds for the retreat period – rainfall retreats starting from Kano, Kaduna, Ilorin, to eventually reach Ibadan, before its final withdrawal from the continent as a result of the withdrawal of southwesterly flowing winds. The observation of the results obtained show that rainfall takes up to 65 days to spread from Ibadan to Kano during the onset period. Whereas, it takes only 30 days to retreat from Kano to Ibadan. This result further corroborates the observations of Ayoade (1974) and Ojo (1977) that ITD advances gradually and retreats rapidly from Nigerian hinterlands. This accounts for the gradual spread of the rain during the onset and rapid retreat during the period of retreat. On the relative efficiency of the use of rainfall amount and rainy days in determining

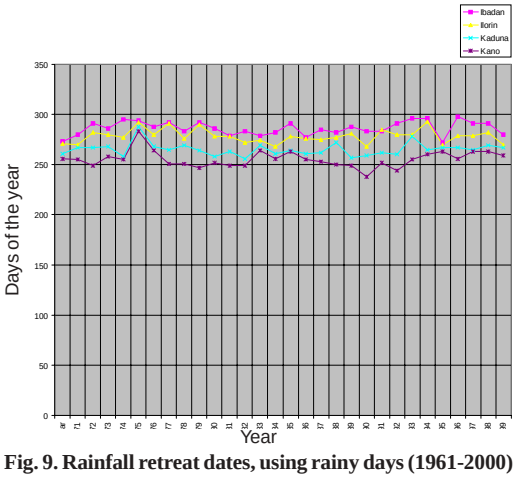

Fig. 9. Rainfall retreat dates, using rainy days (1961-2000)

Table 7: Rainfall onset dates (in days of the year) using rainy days (1971-2000)

Year	*Ibadan*	*Ilorin*	*Kaduna*	*Kano*
1971	71	88	146	173
1972	75	104	133	148
1973	103	113	121	165
1974	91	110	128	155
1975	82	99	121	158
1976	97	101	131	158
1977	98	123	147	157
1978	88	101	118	149
1979	107	110	132	159
1980	103	124	134	148
1981	91	113	124	135
1982	75	100	125	146
1983	109	116	140	152
1984	86	105	137	141
1985	93	100	143	152
1986	85	89	137	165
1987	104	105	151	177
1988	80	103	135	155
1989	120	122	149	171
1990	99	109	130	176
1991	91	102	125	137
1992	106	124	135	140
1993	90	116	138	146
1994	95	103	137	155
1995	76	113	127	163
1996	73	105	142	154
1997	90	116	137	143
1998	102	121	135	152
1999	72	93	135	180
2000	93	103	140	156

Table 8: Rainfall retreat dates (in days of the year) using rainy days (1971-2000)

Year	*Ibadan*	*Ilorin*	*Kaduna*	*Kano*
1971	273	271	261	256
1972	280	270	267	255
1973	291	282	267	249
1974	286	280	268	258
1975	295	277	258	255
1976	294	292	288	283
1977	288	280	268	264
1978	292	291	265	251
1979	283	276	269	251
1980	292	290	264	247
1981	286	278	258	252
1982	279	278	263	249
1983	283	272	256	249
1984	279	274	269	264
1985	282	268	261	256
1986	291	278	264	263
1987	277	276	261	255
1988	285	275	262	253
1989	282	277	272	250
1990	288	281	257	249
1991	283	268	259	238
1992	283	285	262	252
1993	291	280	260	244
1994	296	280	278	255
1995	296	293	265	260
1996	272	270	267	263
1997	298	279	267	256
1998	291	279	265	263
1999	291	282	269	263
2000	280	270	267	259

the rainfall onset and retreat dates, the results obtained show that there is no difference between the two methods with respect to the mean onset and retreat dates in Nigeria. This implies that the required proportion of rainfall amount and rainy days that constitute rainfall onset and retreat dates approximate each other on the long run.

However, the results obtained for the rainfall onset and retreat dates of the individual years proved the method that depends on the rainy days more efficient than that dependent on the rainfall amount. This is as a result of the unrealistic onset and retreat dates observed in the latter method. It is known that rainfall onset in Nigeria is usually foreshadowed by a succession of isolated showers of uncertain amount and intensity with interviewing dry periods of varying duration (Walter, 1967). Thus at the beginning or end of the year, one or two but large isolated showers (as early as first week in January or as late as December) may constitute the specified proportion of the total rainfall amount required for rainfall to be assumed to have commenced or retreated. This situation would definitely generate misleading onset/retreat dates. Whereas, rainfall frequency, in terms of rainy days appear to yield more realistic onset and retreat dates mainly because, no matter how isolated and no matter how large the shower, rainfall becomes frequent only when there is sufficient moisture in the atmosphere for convection and overturning to pace at maximum rate. In other words, the most prominent characteristic of the true rainfall onset and retreat period is rainfall frequency (Walter, 1967; Ilesanmi, 1972a; Ojo, 1977; Adedokun, 1981; Hastenrath, 1985). Thus rainfall commences in earnest at the beginning of the season when rainfall becomes frequent and retreats at the end of the season when rainfall is infrequent.

CONCLUSION

This study examined the relative efficiency of the use of rainfall amount and rainy days in the determination of rainfall onset and retreat dates in Nigeria. The method employed in the

determination of the rainfall onset and retreat dates is percentage cumulative mean rainfall value.

The results obtained showed that both methods (the use of rainfall amount and rainy days) are equally efficient with respect to the mean rainfall onset and retreat dates. With respect to the rainfall onset and retreat dates of the individual years however, the use of rainy days is more efficient as it generates rainfall onset and retreat dates that are more realistic than that generated, using rainfall amount.

The study recommends the use of rainy days rather than the amount, in the determination of rainfall onset and retreat dates of the individual years.

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