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Changing Pattern of Rainfall Amount and Raindays in Samaru, Northern Nigeria and Their Implications on Crop Production

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Abstract The rainfall amount and number of rainy days determines the length of growing season, which equally determines the types of crops to be planted in a particular region. This study analyzed the pattern of rainfall in Samaru Zaria, Kaduna State, Northern part of Nigeria from 1961-2017 using data collected from the Institute for Agricultural Research Samaru, Zaria. The result from this research reveals that an inverse relationship exists between the amount of rainfall and the rainy days. Hence, the higher the rainfall amount the lower the rainy days and vice versa. This is attributed to the current change in climate which increases the intensity of annual rainfall but shortens the duration of the rainy days. The equations generated for amount of rainfall pattern was (y= 3.162x - 5270.9) and number of rainy days was obtained as (y = -0.172x + 417.85). As expected, the months of November to March had the lowest mean rainy days (MRDs) <1 day. As a recurrent pattern for the period of study, the onset of appreciable rainy days was observed in the month of April and the number of rainy days increased steadily to reach its peak in August and a sharp decline in October. From the obtained data, the onset and cessation of rainfall could be predicted to fall towards the end of **April** and **September** respectively.

Keywords: *climate change, crops, rainfall trends, rainy days pattern, rainfall onset and cessation*

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1. Introduction

Nigeria is home to over 170 million people who constantly depend mainly on food production obtained from rain-fed agricultural cropping systems. As the population of the country increases the demand for food and energy also increases [1]. This in turn contributes to pronounced global warming effects which is a major factor influencing the world climatic conditions. One major effect of global warming is the variability in rainfall and climate patterns over several biomes of the earth [2].

Shifts in rainfall patterns may lead to an overall drying trend in some ecological regions, and to increased rainfall in other regions, including Africa [3]. Rainfall is likely to become increasingly aggregated, with wet years projected to become wetter and dry years drier, while the frequency of extreme wet and dry years is expected to increase. On an annual (seasonal) time scale, the number of rainfall events is likely to decrease, while rainfall intensity is likely to increase due to greater atmospheric moisture retention with increased air temperatures. Potential manifestations of increased seasonal variability include more extreme hot days during the growing season, a shift in rainfall toward heavier but less frequent rainfall events, and longer periods between rains-which, when coupled with increased rates of evapotranspiration under warmer temperatures, which could negatively affect crop growth [4]

This work aimed at examining the changing pattern of rainfall amount and rainy days in Samaru, Kaduna State using rainfall amount and rainy days as a prediction parameter and their effect on crop production with the specific objective of studying the trend of rainfall amount and rainy days in Samaru for 57 years and to examine the pattern of rainy days variation per decade from 1961-2017.

2. Materials and Method

The study area is located in Zaria in the Northern Guinea Savanna zone of Nigeria. Samaru is located at 07° 38E 11° 11N and an altitude of 686m above sea level. The soils found in the area are largely Alfisols and Ultisols [5]. Zaria lies within a region, which has a tropical savanna climate with distinct wet and dry seasons. Adequate rainfall amount is received in Zaria area during

the rain fed cropping periods of June to September [5,6]. The Mean annual rainfall of the study area is reported to be 1015.9 mm with an onset and cessation of rainfall as 21st May and 7th October respectively. The mean maximum air temperature is 29.7°C while the mean minimum air temperature is 13.3°C [7,8]. The study area has a coefficient variation (CV) of 15.2 [8]. Fifty-seven (57) years meteorological rainfall data for Samaru, Kaduna state corresponding to periods of 1961-2017 was used in this study which was sourced from the archives of the Institute for Agricultural Research Meteorological station Ahmadu Bello University Zaria, Kaduna.

Table 1. Mean Rainy-day observed between months in 1960s to 2010s

Months	60s	70s	80s	90s	2000s	2010s	MRDs
JAN	0.1	0	0	0	0	0	0.02
FEB	0.1	0	0.2	0	0	0	0.05
MAR	0.5	0.5	0.4	0.2	0.4	0.57	0.43
APR	5	3.7	2.8	2.9	3.4	3.00	3.47
MAY	8.3	9.1	7.6	10.1	7.8	8.86	8.63
JUN	14.2	9.9	10.5	11	11.2	11	11.3
JUL	16.7	15.4	14.5	13.9	15.7	12.43	14.77
AUG*	19	17.5	17.4	18	18.7	16.00	17.77
SEP	16.5	14.3	13.5	14.1	13.4	14.86	14.44
OCT	3.7	3.9	1.9	5.5	5.1	2.71	3.80
NOV	0.3	0.1	0	0.1	0	0	0.08
DEC	0.1	0	0	0	0	0	0.02

The parameters analyzed included the rainy days and the total amount of rainfall throughout the study period. The rainy days were categorized into decades; 1960s, 1970s, 1980s, 1990s, 2000s and 2010s as shown in Table 1. The MRD was obtained as a benchmark to determine the varying pattern of rainy days over the study period. MRD were obtained by dividing the sum of the monthly rainy days in a decade by the number of years in question. Conversely, the total monthly rain amount was obtained by summation of monthly rainfall amount recorded in a month in the IAR weather station.

$$\text{Mean Rainy days} = \frac{\text{Sum of monthly rainydays across the decades}}{\text{Number ofdecades}}$$

$$\text{Total rainfall}(mm) = \text{Sum of monthly rainfall amount}(\text{Jan to Dec})$$

3. Result and Discussions

From analysis of rainfall and rainy days data as observed in Figure 1 and Figure 2, the average number of the rainy days for individual months in the years and the mean rainy days were deduced. The mean monthly rainy days were grouped into 6 periods which included the 1960s, 1970s, 1980s, 1990s, 2000s and the 2010s.

The mean rainy days for the analyzed periods differed significantly between the months. As expected, the months of November to March had the lowest MRDs (<1 day). Throughout the study years, the onset of appreciable rainy days was observed in the month of April with a mean MRD of 3.5 days. The number of days gradually increased with its peak in August. From the obtained data the onset and cessation of rainfall could be predicted to fall towards the end of April and late September from where it the number of days of rainfall begins to reduce drastically to only about 3.8 days per month in October.

Our finding clearly showed that the month of August had the highest number of rainy days across all the periods, however a decrease from 19.0 days in the 1960s to 16.0s in the 2010s was observed. This may be due to the current challenges with climate change which increases the intensity of annual rainfall but shortens the duration of the rainy days.

On the other hand, the increasing equation of y= 3.162x + 5270.9 of rainfall and a converse decreasing equation of y= -0.172x + 417.85 in the number of rainy days over the study years indicates that the number of rainy days might continue to decrease in the coming years as the rainfall amount and intensity increases [9]. These fluctuating trends implies adverse effect on food security, and agriculture due to factors such as; flooding, droughts, stronger soil erosion, short length of growing season for crops, leaching of nutrients in the soil, crop damage, crop failure, and poor seedling emergence.

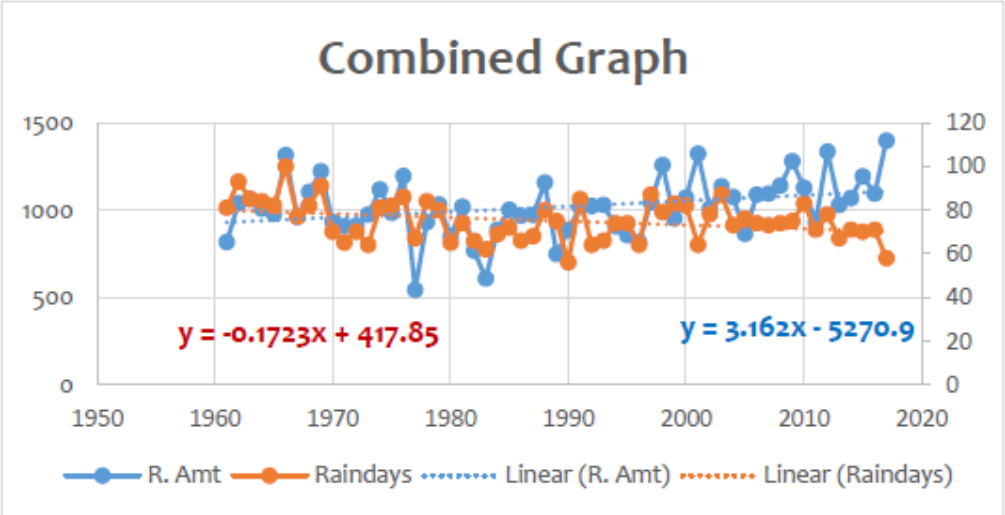

Figure 1. Combined Graph of Rainfall amount trend and rainy days

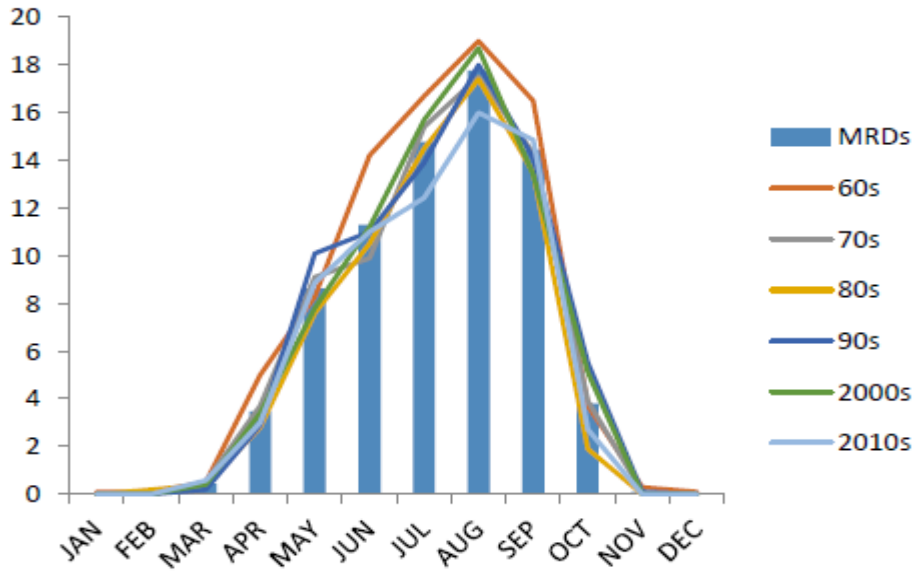

Figure 2. A combined illustration of the monthly Mean Rainy days and the trend observed in the 6 reporting periods (60s, 70s, 80s, 90s, 2000s and 2010s)

4. Conclusion and Recommendations

Historical rainfall and rainy days data obtained from the Meteorological unit of the Institute for Agricultural Research, Ahmadu Bello University Zaria were analyzed for the trends and characteristics of the two parameters. It can be inferred that rainfall amount in the study area is predicted to continually increase with fewer rainy days. This irregular pattern observed in rainfall would pose threat to food security, crop production and the length of growing season in the study area. To mitigate these challenges, further detailed research should be conducted on climate change in other regions of the country and more research Institute for monitoring greenhouse gases should come to limelight. Also, detailed meteorological data and records should be made electronic and accessible in all parts of the country as well as enforcing and implementation of Government policies against illegal deforestation, burning of fossil fuel and unnecessary generation of greenhouse gases.

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APPENDIX

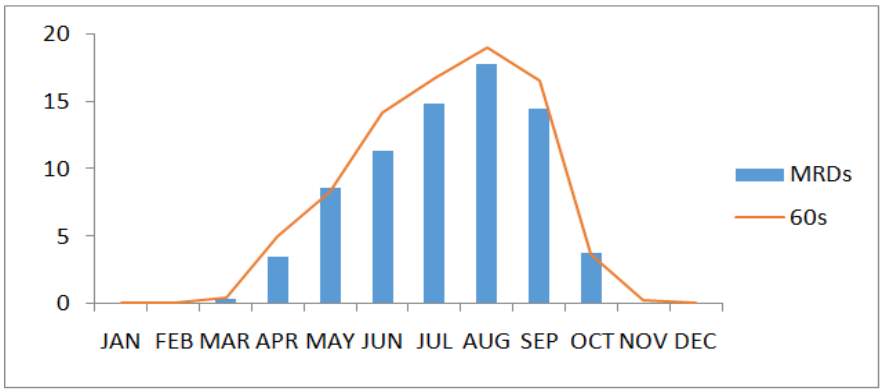

Figure A1. Deviation of Rainy-days of the 60s from Mean Rain days Graph

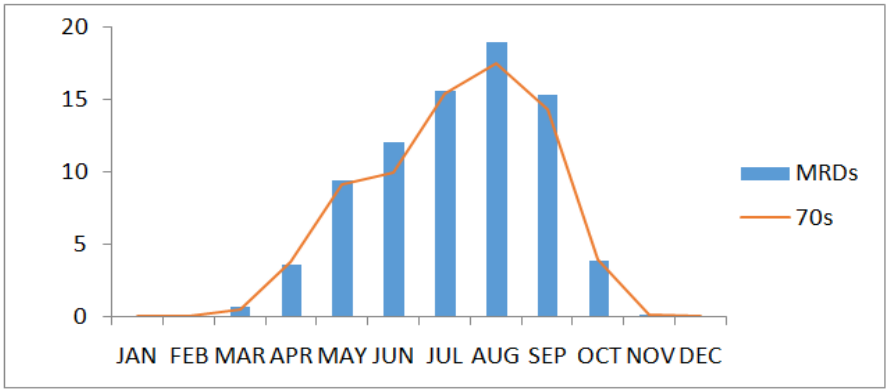

Figure A2. Deviation of Rainy-days of the 70s from Mean Rain days Graph

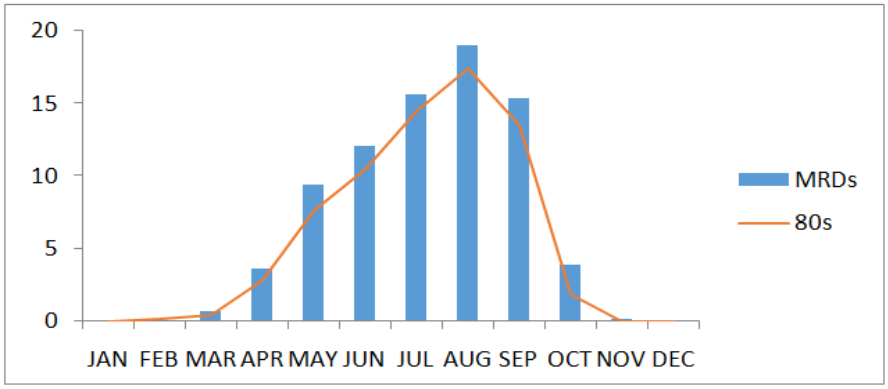

Figure A3. Deviation of Rainy-days of the 80s from Mean Rain days Graph

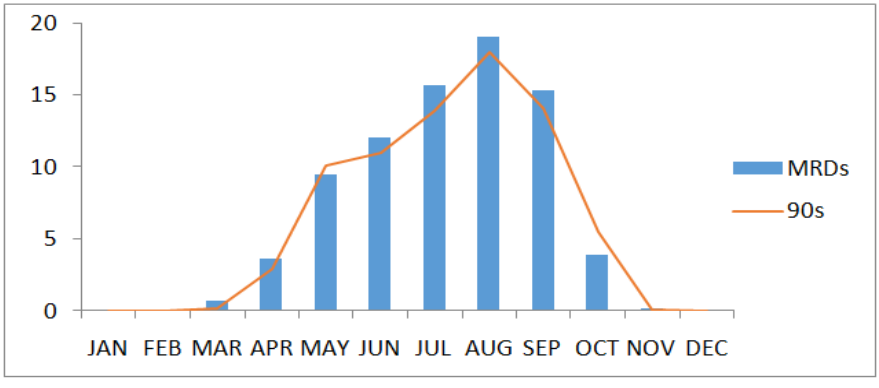

Figure A4. Deviation of Rainy-days of the 90s from Mean Rain days Graph

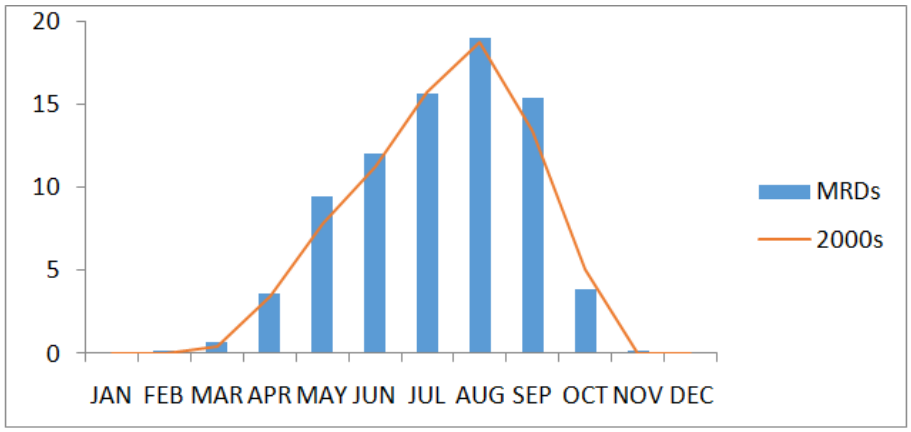

Figure A5. Deviation of Rainy-days of the 2000s from Mean Rain days

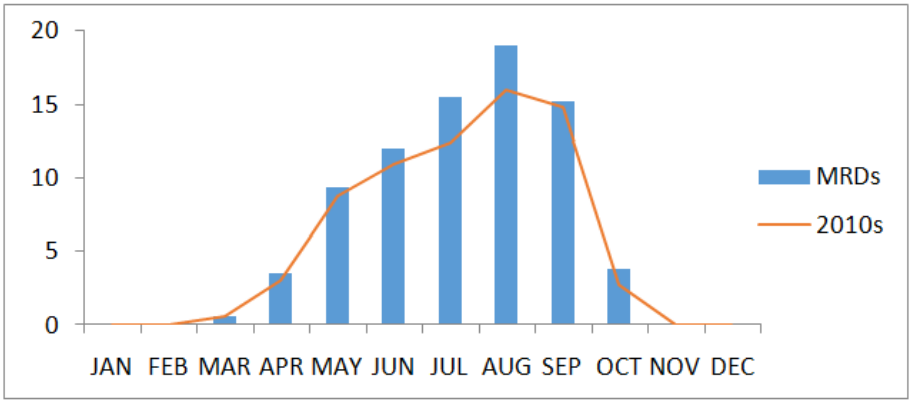

Figure A6. Deviation of Rainy-days of the 2010s from Mean Rainy days graph

Table 2. Yearly rainfall amount and Rainy-day

Year	Raindays	Total Monthly Rainfall amount (mm)
1961	81	817.2
1962	88	1039.8
1963	85	1061.6
1964	84	1006.7
1965	82	978.4
1966	86	1313.5
1967	77	961
1968	82	1103.5
1969	91	1222.2
1970	70	933.5
1971	65	907.1
1972	70	912
1973	64	974.1
1974	81	1116.9
1975	82	983.7
1976	86	1194.9
1977	67	543.7
1978	84	930.3
1979	80	1031
1980	65	847.4
1981	74	1019.1
1982	66	768.5
1983	62	608.2
1984	69	888
1985	72	1000.9
1986	66	968.3
1987	68	971.9
1988	80	1156.7

Year	Raindays	Total Monthly Rainfall amount (mm)
1989	75	747.6
1990	56	884.7
1991	85	1016.5
1992	64	1022.7
1993	66	1028.3
1994	74	907.1
1995	74	856.8
1996	64	817.2
1997	87	1043.2
1998	79	1257.8
1999	83	952.7
2000	82	1069.5
2001	64	1322.3
2002	78	1007.6
2003	87	1135.4
2004	73	1074.9
2005	76	863.7
2006	74	1088.5
2007	73	1093.1
2008	74	1139.9
2009	75	1278
2010	83	1127.3
2011	71	931.3
2012	78	1333.3
2013	67	1028.8
2014	71	1067.5
2015	70	1191.9
2016	71	1093.1
2017	58	1397.6

Table 3. Monthly rainy day from Jan 1961 to Dec 2017

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	1	1	1	5	5	14	22	17	14	0	0	1	81
1962	0	0	0	3	6	13	15	22	22	7	0	0	88
1963	0	0	0	6	7	16	14	17	17	8	0	0	85
1964	0	0	0	5	7	14	19	21	18	0	0	0	84
1965	0	0	0	4	5	18	17	22	15	1	0	0	82
1966	0	0	1	5	9	15	13	21	17	5	0	0	86
1967	0	0	2	5	6	14	16	13	19	2	0	0	77
1968	0	0	0	9	13	12	16	18	13	1	0	0	82
1969	0	0	0	4	11	16	16	20	13	11	0	0	91
1970	0	0	1	1	11	9	17	17	13	1	0	0	70
1971	0	0	1	0	8	6	17	18	13	2	0	0	65
1972	0	0	0	5	10	10	11	18	12	4	0	0	70
1973	0	0	1	2	6	9	11	20	14	1	0	0	64
1974	0	0	1	4	7	9	19	19	18	4	0	0	81
1975	0	0	0	8	11	10	19	13	19	2	0	0	82
1976	0	0	0	6	9	13	15	13	15	15	0	0	86
1977	0	0	0	0	10	13	12	18	13	1	0	0	67
1978	0	0	1	8	14	8	15	19	15	4	0	0	84
1979	0	0	1	2	8	14	19	18	14	3	1	0	80
1980	0	0	0	2	8	7	16	19	10	3	0	0	65
1981	0	0	0	5	9	11	17	19	13	0	0	0	74
1982	0	0	0	10	7	8	10	17	12	2	0	0	66
1983	0	0	0	0	10	9	15	16	12	0	0	0	62
1984	0	0	1	6	8	9	17	11	11	6	0	0	69
1985	0	0	3	0	8	9	17	18	15	2	0	0	72
1986	0	0	0	1	6	9	17	17	16	0	0	0	66
1987	0	0	0	0	7	13	10	21	14	3	0	0	68
1988	0	2	0	5	7	14	14	20	17	1	0	0	80

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1989	0	0	0	1	13	11	13	19	13	5	0	0	75
1990	0	0	0	0	1	12	15	16	12	0	0	0	56
1991	0	0	2	6	19	11	16	19	10	2	0	0	85
1992	0	0	0	1	9	7	16	16	11	3	1	0	64
1993	0	0	0	4	12	9	12	15	11	3	0	0	66
1994	0	0	0	5	7	11	9	21	11	10	0	0	74
1995	0	0	0	4	4	12	13	22	16	3	0	0	74
1996	0	0	0	0	11	9	10	12	16	6	0	0	64
1997	0	0	0	3	11	13	14	19	17	10	0	0	87
1998	0	0	0	3	10	12	11	20	16	7	0	0	79
1999	0	0	0	3	6	12	20	17	18	7	0	0	83
2000	0	0	0	0	12	14	18	19	15	4	0	0	82
2001	0	0	0	5	6	9	15	16	13	0	0	0	64
2002	0	0	2	4	3	12	17	19	15	6	0	0	78
2003	0	0	0	4	7	10	20	23	17	6	0	0	87
2004	0	0	1	1	9	12	17	21	9	3	0	0	73
2005	0	0	0	3	11	11	18	17	12	4	0	0	76
2006	0	0	0	1	10	12	14	15	16	6	0	0	74
2007	0	0	1	4	10	15	12	21	8	2	0	0	73
2008	0	0	0	3	9	9	15	18	13	7	0	0	74
2009	0	0	0	4	6	11	14	19	14	7	0	0	75
2010	0	0	0	5	7	11	15	18	17	10	0	0	83
2011	0	0	0	3	11	12	14	16	12	3	0	0	71
2012	0	0	0	4	16	9	12	16	17	4	0	0	78
2013	0	0	0	5	7	8	15	17	14	1	0	0	67
2014	0	0	0	8	9	10	10	14	16	4	0	0	71
2015	0	0	1	0	7	7	14	19	16	6	0	0	70
2016	0	0	3	1	11	16	10	16	14	0	0	0	71
2017	0	0	0	0	1	15	12	14	15	1	0	0	58

Table 4. Daily rainfall amount (mm) Jan 1961 to Dec 2017

Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	10.2	49.2	66.7	82.3	160.5	312.8	120.3	13.6	1.6	0	817.2
1962	0	0	0.7	17.0	55.4	174.0	321.8	395.3	61.7	13.9	0	0	1039.8
1963	0	0	11.3	55.9	144.9	211.2	233.5	342.8	55.7	6.4	0	0	1061.65
1964	0	0	0.4	59.4	69.0	155.8	180.4	387.8	132.7	21.2	0	0	1006.7
1965	0	0	2.1	22.4	89.4	139.7	227.4	340.3	145.0	12.1	0	0	978.4
1966	0	0	1.9	51.8	137.7	265.7	306.4	401.1	118.5	18.6	11.8	0	1313.5
1967	0	0	2.6	28.9	119.9	126.9	198.8	369.2	114.7	0	0	0	961
1968	0	0	0.3	85.8	143.5	125	233.3	326.3	138.9	6.9	43.5	0	1103.5
1969	0	0.3	0	43.1	116.9	182.9	445.3	239.3	89.9	104.5	0	0	1222.2
1970	0	0	6.9	1.8	131.4	127.8	259	257.9	142.1	6.6	0	0	933.5
1971	0	0	3.6	0	116.9	31.4	231	321.6	195	7.6	0	0	907.1
1972	0	0	0.3	55.3	135.9	112.8	172.5	325.7	85.3	24.2	0	0	912
1973	0	0	0.5	21.6	46.9	191.7	191.8	227.5	292.6	1.5	0	0	974.1
1974	0	0	11.2	30	33.8	144.3	253	329	247	68.6	0	0	1116.9
1975	0	0	0.3	85.8	130.3	146.7	292.5	151	169.3	7.8	0	0	983.7
1976	0	0	0	86.3	135.5	233.5	207.3	219.6	154.7	158	0	0	1194.9
1977	0	0	0	0	78.3	101.7	56.7	302.7	4.3	0	0	0	543.7
1978	0	0	1.3	77.7	191.5	164.7	145.3	315.9	33.9	0	0	0	930.3
1979	0	0	10.4	19.8	86.3	220.2	357.2	299.8	27.5	9.8	0	0	1031
1980	0	0	0	2	156.1	116.4	260.9	221.4	74.3	16.3	0	0	847.4
1981	0	0	0	100.7	90.7	159	254.8	280.6	133.3	0	0	0	1019.1
1982	0	0	0	59.7	72.1	113.9	168.7	190.7	117.6	45.8	0	0	768.5
1983	0	0	0	0	73.3	74.3	107.5	259.7	93.4	0	0	0	608.2
1984	0	0	5.2	21.1	107.9	55.4	173.8	158.1	189	177.5	0	0	888
1985	0	0	32.9	0.7	140.7	142.2	313.1	204.7	163.3	3.3	0	0	1000.9
1986	0	0	0	5.8	59.1	82	293.6	322.1	205.7	0	0	0	968.3
1987	0	0	0	0	135.7	146.8	276.7	268	102.1	42.6	0	0	971.9
1988	0	3.5	0	34.6	86.5	139.2	183.4	402.5	192.3	114.7	0	0	1156.7

Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1989	0	0	0	15	113	124.4	153.6	160.9	127.8	52.9	0	0	747.6
1990	0	0	0	0	120.3	155.7	221.9	255.3	131.5	0	0	0	884.7
1991	0	0	44.7	47.8	238.9	87.2	189.6	328.4	51.2	28.7	0	0	1016.5
1992	0	0	0	32.3	73.1	112.4	234.5	298.2	229.7	39.9	2.6	0	1022.7
1993	0	0	0	7.5	113.6	156.4	269	300.8	148.6	32.4	0	0	1028.3
1994	0	0	0	18.9	120.1	231.9	169.2	215.3	82.5	69.2	0	0	907.1
1995	0	0	0	90.5	45.3	125.2	155.6	248.6	159.1	32.5	0	0	856.8
1996	0	0	0	0	125.9	174.7	158.1	161	146.3	51.2	0	0	817.2
1997	0	0	0	47.6	86.4	155.2	213.8	280.2	178.6	81.4	0	0	1043.2
1998	0	0	0	110	92.8	129.6	196.4	473.6	209.8	45.6	0	0	1257.8
1999	0	0	0	7.9	23.4	238.3	285.5	154.8	204.2	38.6	0	0	952.7
2000	0	0	0	0	136.4	206.5	194.3	272	182.1	78.2	0	0	1069.5
2001	0	0	0	83.9	160.3	177.7	267.8	360.9	271.7	0	0	0	1322.3
2002	0	0	19.9	69.6	10.6	133.1	229	201.4	218.8	125.2	0	0	1007.6
2003	0	0	0	31	78.4	69.2	243.1	427.1	219.5	67.1	0	0	1135.4
2004	0	0	13.6	7.8	113.5	234.2	191.3	311.8	181.9	20.8	0	0	1074.9
2005	0	0	0	63.1	113.1	160.2	152.6	235.5	122.4	16.8	0	0	863.7
2006	0	0	0	1.8	202.5	126.5	232.2	222	275	28.5	0	0	1088.5
2007	0	0	1.7	58.7	169.4	220.2	238.6	364.3	31.9	8.3	0	0	1093.1
2008	0	0	0	72.6	95.2	109.1	201.5	355	217.5	89	0	0	1139.9
2009	0	0	0	20.3	85.1	89.5	285	439.7	206.7	151.7	0	0	1278
2010	0	0	0	52.4	92.9	158.3	216.8	313.4	211.2	82.3	0	0	1127.3
2011	0	0	0	13.9	123.3	162.5	223.9	239.9	113.8	54	0	0	931.3
2012	0	0	0	5.6	173.6	210.8	101.6	379.6	338.7	106.7	16.7	0	1333.3
2013	0	0	0	73.8	66.5	167	314.9	163	233	10.6	0	0	1028.8
2014	0	0	0	141.7	127.2	119.1	115.7	374.3	180.2	9.3	0	0	1067.5
2015	0	0	90.9	0	53.2	103	189.3	319.2	374.4	61.9	0	0	1191.9
2016	0	0	1.7	58.7	169.4	220.2	238.6	364.3	31.9	8.3	0	0	1093.1
2017	0	0	0	2.4	120.6	144.7	232.1	638.1	256.7	3	0	0	1397.6

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