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EL NIÑO AND LA NIÑA EVENTS AND RAINFALL IN NE AND SOUTH BRAZIL

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The relationship between El Niño (warm episodes) and La Niña (cold episodes) and rainfall in NE and South of Brazil is very loose. In some El Niño years, the rainfall at Fortaleza in DJF (December, January, February) could be above average while rainfall in MAM (March, April, May) may be below average (or vice-versa). On the average, deviations at Fortaleza (CE, NE Brazil) are slightly negative and those at Porto Alegre and Bagé (RS, South Brazil) are slightly positive during El Niño years. However, for individual events, the deviations can be from large positive to large negative. Hence, predictions can be very uncertain and hazardous.

OS FENÔMENOS EL NIÑO E LA NIÑA E PRECIPITAÇÃO NO NORDESTE E SUL DO BRASIL *A relação entre os fenômenos El Niño (águas quentes) e La Niña (águas frias) e as chuvas no Nordeste e Sul do Brasil é fraca. É possível acontecer que em certos anos de El Niño, as chuvas em Fortaleza durante os meses de dezembro, janeiro e fevereiro (DJF) sejam acima do normal e durante os meses de março, abril e maio (MAM) sejam abaixo do normal ou vice-versa. Em média, durante os acontecimentos de El Niño, as chuvas em Fortaleza (CE, NE Brasil) têm pequeno decréscimo e no Sul, em Porto Alegre e Bagé (RS, South Brasil), um pequeno acréscimo. Porém, para eventos individuais, os desvios podem variar entre valores enormemente positivos a enormemente negativos. Portanto, as previsões podem ser muito incertas e perigosas.*

INTRODUCTION

In earlier communications (Kane and de Souza, 1988; Kane, 1989) it was indicated that the relationship between rainfall at Fortaleza, Ceará (NE Brazil) and El Niño events was very loose. Out of the 29 El Niño events, which occurred during 137 years (1849-1985), only 12 were associated with droughts in Fortaleza. Conversely, out of the 23 major droughts in Fortaleza (negative departures exceeding -37% of rainfall) only 5 (1877, 1891, 1902, 1958, 1983) were associated with strong and moderate El Niños. Only in the southern part of Brazil, some relationship was indicated. In Porto Alegre, during 70 years (1916-1985), out of 15 strong and moderate El Niños, 9 (60%) were associated with floods.

Yet, the myth seems to persist. Every time El Niño occurs, droughts in NE Brazil are predicted. So

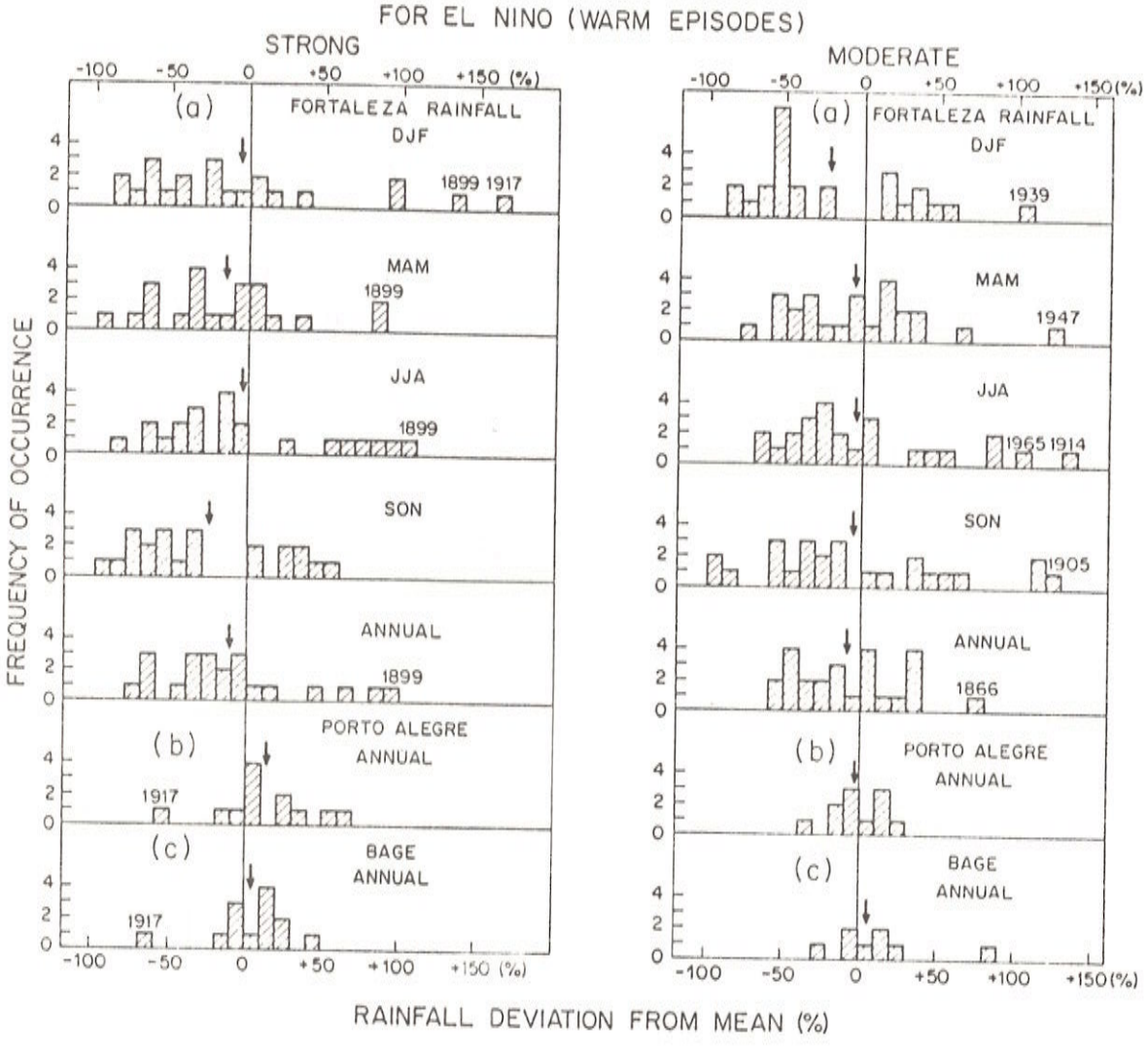

Figure 1. Frequency of ocurrences of percentage deviations of (a) quarterly and annual rainfall at Fortaleza, (b) annual rainfall at Porto Alegre, (c) annual rainfall at Bagé for El Niño (warm episode) years. Left half: Strong and Very Strong El Niños. Right half: Moderate and Near Moderate El Niños. The arrows indicate mean values of the percentage deviations.

Freqüência de ocorrência dos desvios percentuais de (a) precipitação anual em Porto Alegre , (c) precipitação anual em Bagé para anos de El Niño (episódio quente). Painel esquerdo: Casos de El Niño intenso e muito intenso. Painel direito: Casos de El Niño moderado e quase moderado. As setas indicam valores médios dos desvios percentuais.

much so that, during the present drought in NE Brazil (May-Aug 1992), the TV report claimed that a warning was issued several months back when El Niño appeared in early part of 1992 and action should have been taken. Thus, a feeling is created that El Niños and NE Brazil droughts have an almost one-to-one relationship.In this note, the rainfall data in Fortaleza are reexamined on a quarterly (DJF = December, January, February; MAM = March, April, May; JJA = June, July, August; SON = September, October, November) as well as annual basis to see whether any relationship can be discerned either with El Niño (warm episodes) or with La Niña (cold episodes).

DATA

Data for Fortaleza rainfall were obtained from SUDENE and those for Porto Alegre and Bagé from DNEMET (National Department of Meteorology). For El Niño events (warm episodes), classifications given by Quinn et al. (1978, 1987), Rasmusson and Carpenter (1983) and Gray (1984) were used. For La Niña (cold episodes), the listing given by Kiladis and Diaz (1989) was used.

ANALYSIS

Table 1 and 2 show the rainfall in Fortaleza (CE) for the four quarters (DJF, MAM, JJA, SON) as also for the whole year (annual). The mean values for these were 314, 869, 197, 50, and 1430 mm respectively for the interval 1849-1978 and are indicated at the top. The annual mean varies considerably from year to year, the maximum exceeding 2500 mm and the minimum dropping below 600 mm and the series having a standard deviation of 490 mm ($\sim$ 35%). The first column indicates the strength of the El Niño, VS = very strong, S = strong in Table 1, and M = Moderate and W/M = Near Moderate in Table 2. The second column indicates the years of El Niño occurrence. The 3rd to 7th columns give the rainfall (mm) in the four quarters and the annual rainfall in Fortaleza. The last two columns give the annual rainfalls in Porto Alegre and Bagé (RS). The numbers in brackets give the rainfalls expressed as percentage deviations from the respective means (given at the top). From Table 1, the following may be noted:

(1) Even though all events are strong or very strong El Niños, the percentage deviations have a very wide range, from large negative to large positive values. The frequency distribution is shown in Fig. 1, left half. For all the quarters as also for the annual plot, the deviations are spread all over. The mean values (indicated by arrows in Fig. 1) are 0 - 20% negative (lesser than the std. dev. 35%), thus indicating a weak negative relationship on the average.
(2) The distributions are not similar for all quarters. In Table 1, values are often of opposite signs in consecutive quarters. For example, there might occur deficit rainfall in DJF and excess rainfall in MAM or vice-versa. In other words, good rainfall in the initial stages could be followed by shortage of rainfall in the main season, or vice-versa. This is rather intriguing, because, in his model for prediction of NE Brazil rainfall anomalies, Hastenrath (1990) uses OJ (October-January) rainfall as one of the predictors, as it accounts for more than 50% of the interannual MS (March to September) variance. In some years, the relationship between DJF and MAM may be worse than in other years, thus spoiling the predictions.
(3) For Porto Alegre (Fig. 1b) and Bagé (Fig. 1c) in South Brazil, the values are spread on both sides (positive and negative) though the mean is 0 - 20% positive. Thus, strong El Niños do not necessarily ensure floods in the south. There can occur even droughts in some El Niño years. The El Niño of 1917 seems to have caused excess rains in DJF and normal rains in MAM in Fortaleza and large annual deficits in Porto Alegre and Bagé.

(4) The El Niño of 1899 and the second year El Niños of 1912 and 1973 seem to have caused excess rains in Fortaleza (not droughts).

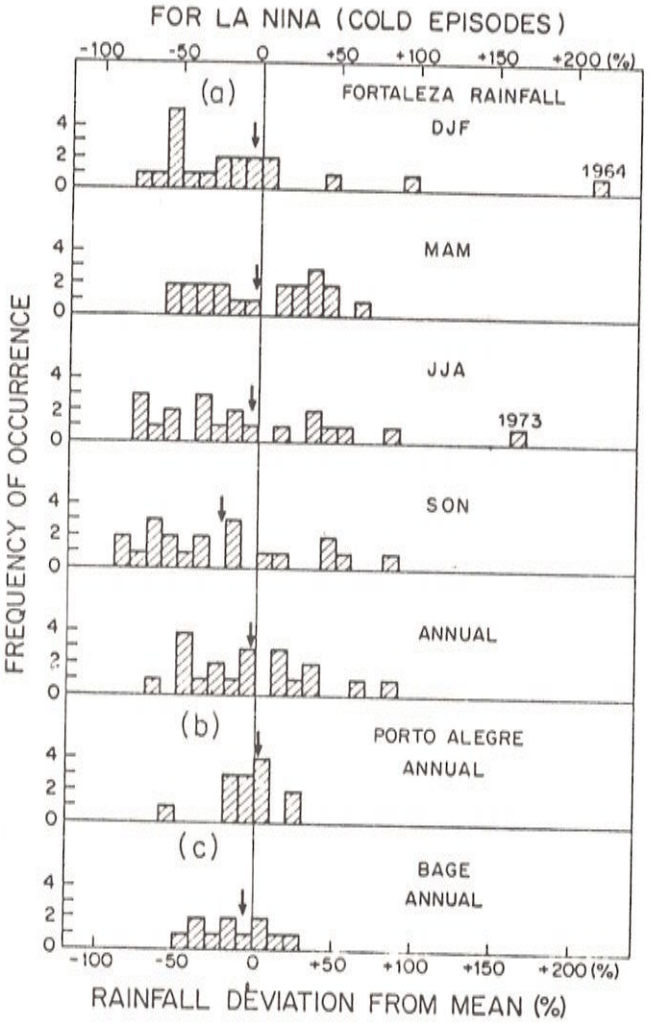

Figure 2. Same as Fig. 1, but for la Niña (cold episodes) years (Kiladis and Diaz, 1989).
Mesmo que na Fig. 1, porém para casos de El Niña (episódio frio; Kiladis e Diaz, 1989).

Table 1. The rainfall (mm and percentage deviations from mean) at Fortaleza for the four quarters as well as annual rainfall at Fortaleza (CE) and Porto Alegre and Bagé (RS, South Brazil) during El Niño years. The first column indicates the strength (S = strong, VS = very strong, M = moderate, W/M = near moderate) of the El Niños and the second column indicates the years. Numbers in brackets are percentage deviations from the means indicated at the top. Average percentage deviations are given at the bottom, for Strong and Very Strong El Niños.

Precipitação em Fortaleza (em mm e desvios percentuais da média) para os quatro trimestres, assim como precipitação anual em Fortaleza (CE) e Porto Alegre e Bagé (RS) durante anos de El Niño. A primeira coluna indica a intensidade (S = intenso, VS = muito intenso, M = moderado, W/M = quase moderado) de eventos El Niño e a segunda coluna indica os anos. Números entre parenteses são desvios percentuais da média indicada acima. Desvios percentuais médios são dados no final da Tabela para casos de El Niños intensos e muito intensos.

		Fortaleza					Porto Alegre	Bagé
Mean (mm)		314	869	197	50	1430	1288	1374
Category	Year	DJF	MAM	JJA	SON	Annual	Annual	Annual
S	1864	292	672	134	15	1113		
		(-7)	(-23)	(-32)	(-70)	(-22)		
S^+	1871	111	813	341	65	1330		
		(-65)	(-6)	(+73)	(+30)	(-7)		
VS	1877	41	226	174	28	469		
		(-87)	(-74)	(-12)	(-44)	(-67)		
	1878	119	351	31	2	503		
		(-62)	(-60)	(-84)	(-96)	(-65)		
S+	1884	64	847	74	60	1045		
		(-80)	(-3)	(-62)	(+20)	(-27)		
VS	1891	171	596	120	33	920		
		(-46)	(-31)	(-39)	(-34)	(-36)		
S	1899	741	1615	415	24	2795		
		(+136)	(+86)	(+110)	(-52)	(+95)		
	1900	129	75	165	6	373		
		(-60)	(-91)	(-16)	(-88)	(-74)		
S	1911	421	864	300	20	1605		
		(+34)	(-1)	(+52)	(-60)	(+12)		
	1912	625	1603	386	63	2677		1358
		(+99)	(+84)	(+96)	(+26)	(+87)		(-1)
S	1917	847	951	181	75	2054	644	514
		(+170)	(+9)	(-8)	(+50)	(+44)	(-50)	(-63)
VS	1925	363	756	88	54	1261	1144	1378
		(+16)	(-13)	(-55)	(+8)	(-12)	(-11)	(0)
	1926	324	981	132	23	1460	1273	1527
		(+3)	(+13)	(-33)	(-54)	(+2)	(-1)	(+11)
S	1932	342	323	182	33	880	1344	1421
		(+9)	(-63)	(-8)	(-34)	(-38)	(+4)	(+3)

Table 1 (Continued)

		Fortaleza					Porto Alegre	Bagé
Mean (mm)		314	869	197	50	1430	1288	1374
Category	Year	DJF	MAM	JJA	SON	Annual	Annual	Annual
S	1940	244	892	244	33	1413	1776	1933
		(-22)	(+3)	(+24)	(-34)	(-1)	(+38)	(+41)
	1941	226	583	109	13	931	2100	1787
		(-28)	(-330	(-45)	(-74)	(-35)	(+63)	(+30)
S	1957	149	939	67	53	1208	1372	1146
		(-53)	(+8)	(-66)	(+6)	(-16)	(+7)	(-17)
	1958	69	267	171	14	521	1325	1347
		(-78	(-69)	(-13)	(-72)	(-64)	(+3)	(-2)
S	1972	163	554	552	17	1286	1985	1614
		(-48)	(-36)	(+80)	(-66)	(-10)	(+54)	(+17)
	1973	600	1167	516	79	2362	1362	1573
		(+91)	(+34)	(+62)	(+58)	(+65)	(+6)	(+14)
VS	1982	247	557	168	67	1039	1651	1623
		(-21)	(-36)	(-15)	(+34)	(-27)	(+28)	(+18)
	1983	267	445	106	21	839	1618	1718
		(-15)	(-49)	(-46)	(-58)	(-41)	(+26)	(+25)
AVERAGE (%)								
Single events	(6)	(-3)	(-20)	(-13)	(-6)	(-14)	(- 23)	(-30)
All events	(22)	(-5)	(-16)	(-2)	(-27)	(-11)	(+14)	(+6)

Table 2 shows results for moderate and near moderate El Niños. Here again, there is a wide range of rainfall deviations. In several cases, DJF was negative and MAM was positive. The average values were slightly negative for Fortaleza and slightly positive for Porto Alegre and Bagé. Fig. 1 (right half) shows the plots, which seem similar to those in Fig. 1 (left half), thus indicating that the pattern of spread of deviations has probably other origins, different from El Niño relationships.

In between El Niños (warm episodes), there are years of La Niña (cold episodes). Kiladis and Diaz (1989) have given a listing which forms the first column of our Table 3. Other columns are similar to our Tables 1 and 2. As can be seen, there is again a large scatter. The average values are small negative for Fortaleza and Bagé and small positive for Porto Alegre. A scatter similar to that in Tables 1 and 2, again indicates that the deviations have very little relationship with El Niño or with La Niña.

CONCLUSIONS AND DISCUSSION

It is obvious, therefore, that any predicition based on El Niño or La Niña occurrence will have very little credibility. There would be years when such a prediction could turn out to be grossly erroneous (large floods instead of droughts in NE Brazil) as in 1899, 1912, 1917, 1973. It should also be remembered that the rainfall patterns are not alike in the whole of NE Brazil.

Patterns could be different, even in different parts of the same state (Kousky and Chu, 1978; Kousky, 1979). The relationship between El Niño and the rainfall in different parts of NE and East Brazil was very poor, except in the south of Brazil (Kane and de Souza, 1988). As such, general predictions like strong El Niño would cause droughts in NE Brazil and floods in south Brazil may prove foolhardy and may turn out to be true only by chance. A lack of good linear correlation between El Niño and rainfall

Table 2. Same as Table 1, but for moderate and near moderate El Niños.

Como na Tabela 1, porém, para casos de El Niños moderados e quase moderados.

		Fortaleza					Porto Alegre	Bagé
Mean (mm)		314	869	197	50	1430	1288	1374
Category	Year	DJF	MAM	JJA	SON	Annual	Annual	Annual
M	1866	158	1947	293	68	2466		
		(-50)	(+124)	(+49)	(+36)	(+72)		
M	1867	89	590	153	9	841		
		(-72)	(-32)	(-22)	(-82)	(-41)		
	1868	353	640	212	59	1264		
		(+12)	(-26)	(+8)	(+18)	(-12)		
M	1874	356	816	299	42	1513		
		(+13)	(-6)	(+52)	(-16)	(+6)		
M	1880	55	1139	262	51	1507		
		(-82)	(+31)	(+33)	(+2)	(+5)		
V/M	1887	222	1035	69	4	1330		
		(-29)	(+19)	(-65)	(-92)	(-7)		
	1888	159	381	182	3	725		
		(-49)	(-56)	(-8)	(-94)	(-49)		
	1889	156	446	132	31	765		
		(-50)	(-49)	(-33)	(-38)	(-47)		
M+	1896	144	1412	362	76	1994		
		(-54)	(+62)	(+84)	(+52)	(+39)		
	1897	424	1078	366	72	1940		
		(+35)	(+24)	(+86)	(+44)	(+36)		
M+	1902	156	524	150	33	863		
		(-50)	(-40)	(-24)	(-34)	(-40)		
W/M	1905	122	892	77	108	1199		
		(-61)	(+3)	(-61)	(+116)	(-16)		
M	1907	130	380	145	43	698		
		(-59)	(-56)	(-26)	(-14)	(-51)		
M+	1914	422	1011	462	23	1918		2470
		(+34)	(+16)	(+135)	(-54)	(+34)		(+80)

Table 2 (Continued)

		Fortaleza					Porto Alegre	Bagé
Mean (mm)		314	869	197	50	1430	1288	1374
Category	Year	DJF	MAM	JJA	SON	Annual	Annual	Annual
W/M	1918	361	1177	159	68	1765	1058	1615
		(+15)	(+35)	(-19)	(+36)	(+23)	(-18)	(+18)
	1919	175	239	139	109	662	1531	1516
		(-44)	(-72)	(-29)	(+118)	(-54)	(+19)	(+10)
M	1923	402	1018	129	24	1573	1213	
		(+28)	(+17)	(-35)	(-52)	(+10)	(-6)	
W/M	1930	246	602	203	26	1077	1557	1661
		(-22)	(-31)	(+3)	(-48)	(-25)	(+21)	(+21)
	1931	446	609	83	30	1171	1226	
		(+42)	(-30)	(-58)	(-40)	(-18)	(-5)	
M+	1939	631	983	162	111	1887	1378	1075
		(+101)	(+13)	(-18)	(+122)	(+32)	(+7)	(-22)
M+	1943	105	716	134	40	995	807	933
		(-67)	(-18)	(-32)	(-20)	(-30)	(-37)	(-32)
W/M	1951	30	423	213	81	747	1070	
		(-90)	(-51)	(+8)	(+62)	(-48)	(-17)	
M+	1953	139	780	107	41	1067	1266	1216
		(-56)	(-10)	(-46)	(-18)	(-25)	(-2)	(-11)
M+	1965	137	1072	403	22	1634	1518	1632
		(-56)	(+23)	(+105)	(-56)	(+14)	(+18)	(+19)
M	1976	500	830	117	38	1485	1552	1355
		(+59)	(-4)	(-41)	(-24)	(+4)	(+20)	(-1)
M	1986	681	1204	320	81	2286		
		(+169)	(+39)	(+62)	(+62)	(+60)	-	-
M	1987	258	581	308	30	1177		
		(-18)	(-33)	(+56)	(-40)	(-18)	-	
AVERAGE (%)								
Single events	(14)	(-24)	(+3)	(+4)	(+4)	(-2)	(-2)	(+5)
All events	(27)	(-15)	(-4)	(+4)	(-2)	(-6)	(0)	(+9)

Table 3. Same as Table 1 and 2, but for La Niña (cold episodes) obtained from Kiladis and Diaz (1989).
Como nas tabelas anteriores, porém para casos de La Niña (episódios frios) obtidos de Kiladis e Diaz (1989).

	Fortaleza					Porto Alegre	Bagé
Mean (mm)	314	869	197	50	1430	1288	1374
Year	DJF	MAM	JJA	SON	Annual	Annual	Annual
1886	269	1020	95	23	1407		
	(-14)	(+17)	(-52)	(-54)	(-2)		
1889	156	446	132	31	765		
	(-50)	(-49)	(-33)	(-38)	(-47)		
1892	117	731	175	45	1068		
	(-63)	(-16)	(-11)	(-10)	(-25)		
1898	77	369	41	11	498		
	(-75)	(-58)	(-79)	(-78)	(-65)		
1903	298	426	52	21	797		
	(-5)	(-51)	(-74)	(-58)	(-44)		
1906	322	963	126	18	1429		
	(+3)	(+11)	(-36)	(-64)	(0)		
1908	168	479	142	44	833		
	(-46)	(-45)	(- 28)	(-12)	(-42)		
1916	243	1124	177	31	1625	1301	1068
	(-23)	(+35)	(-10)	(-38)	(+14)	(+1)	(-22)
1920	155	1128	223	70	1576	1077	1436
	(-51)	(+30)	(+13)	(+40)	(+10)	(-16)	(+5)
1924	303	1276	300	57	1936	609	820
	(-4)	(+47)	(+52)	(+14)	(+ 35)	(-53)	(-40)
1928	190	671	67	18	946	1604	1699
	(-39)	(-23)	(-66)	(-64)	(-34)	(+25)	(+24)
1931	446	609	83	30	1168	1226	
	(+42)	(-30)	(-58)	(-40)	(-18)	(-5)	
1938	244	1103	183	70	1600	1388	896
	(-22)	(+27)	(-7)	(+40)	(+12)	(+8)	(-35)
1942	130	590	46	7	773	1217	1163
	(-59)	(-32)	(-77)	(-86)	(-46)	(-6)	(-15)
1949	148	1455	267	19	1889	1159	
	(-53)	(+67)	(+36)	(-62)	(+32)	(-10)	
1954	265	633	127	10	1035	1609	1399
	(-16)	(-27)	(-36)	(-80)	(-28)	(+25)	(+2)

Table 3 (Continued)

Fortaleza						Porto Alegre	Bagé
Mean (mm)	314	869	197	50	1430	1288	1374
Year	DJF	MAM	JJA	SON	Annual	Annual	Annual
1964	1007 (+220)	1258 (+45)	267 (+36)	91 (+82)	2623 (+83)	1040 (-19)	909 (-34)
1970	136 (-57)	854 (-2)	363 (+84)	41 (-18)	1394 (-3)	1273 (-1)	1362 (-1)
1973	600 (+91)	1167 (+34)	516 (+162)	79 (+58)	2362 (+65)	1362 (+6)	1573 (+14)
1965	340 (+8)	1102 (+27)	294 (+49)	53 (+6)	1789 (+25)	1288 (0)	1156 (-16)
1988	447 (+42)	1081 (+24)	369 (+87)	81 (+62)	1978 (+38)	-	-
AVERAGE (%)							
Events (21)	(-8)	(+1)	(-3)	(-19)	(-2)	(+2)	(-11)

in NE Brazil is not surprising. Several other factors can spoil such a relationship e.g. 700 mb circulation pattern over the North Atlantic (Namias, 1977), meridional displacement and strength of the Intertropical Convergence Zone (ITCZ) (Hastenrath and Heller, 1977), rainfall systems associated with tropical disturbances moving westward from the Atlantic towards NE Brazil (Ramos 1975, Yamazaki and Rao, 1977), southern hemisphere cold fronts or their remains moving northeastward along the northeast coast of Brazil (Kousky and Chu 1978; Kousky 1979); etc. Hastenrath (1990) proposed a scheme in which three predictors viz. OJ (October-January rainfall), AFV (meridional wind components of tropical Atlantic between 30°N and 30°S) and PWT (sea surface temperature in the equatorial Pacific) explained ~ 70% variance. Apart from the fact that ~ 30% variance is still unexplained, some of the parameters are difficult to get well in time for predictions to be possible. Thus, it seems to be a long way still before a good prediction rainfall in NE Brazil is possible.

Incidentally, a spectral analysis of the rainfall series for Northeast Brazil for 1912-1978 yielded some significant periodicities, notably 13 and 26 years (Kane and Trivedi, 1988). All these explained only about 30% variance. But extrapolation to future years (after 1978, details given in Kane and Trivedi, 1988), indicated likely droughts during 1992-1994 and 2002-2006. Maybe the deficit rainfall of 1992 is a rough support of the prediction. One needs confirmation in 1993 and 1994. Also, the prediction needs to be updated by using data up to 1991 so that the effects of the El Niño of 1986-87 and the La Niña of 1988-89 may be incorporated.

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