

# LIMITED EFFECTIVENESS OF EL NIÑOS IN CAUSING DROUGHTS IN NE BRAZIL AND THE PROMINENT ROLE OF ATLANTIC PARAMETERS

Rajaram P. Kane

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Though El Niños are popularly believed to be associated with droughts in NE Brazil, not all El Niños are effective. During 1871-1998, there were 52 El Niños, out of which 31 were associated with droughts and 21 were not associated. The failures are mainly due to the intervention of conditions in the Atlantic. The mass media needs to take this into account and minimize their exaggerated expectations of droughts during El Niño years.

**Key words:** El Niños; Droughts; NE Brazil; Atlantic.

**EFETIVIDADE LIMITADA DE EL NIÑOS EM CAUSAR SECAS NO NE DO BRASIL E O PAPEL PROEMINENTE DOS PARÂMETROS DO ATLÂNTICO** - Embora popularmente acredita-se que os El Niños estejam associados à secas no nordeste do Brasil, nem todos os El Niños são efetivos. Durante 1871-1998 houveram 52 eventos El Niños, dos quais 31 estiveram associados com secas e 21 não estiveram. Estas falhas estão principalmente associadas às condições do Atlântico. A Mídia de massa precisa levar isto em conta e minimizar sua exagerada expectativa de secas durante os anos de El Niño.

**Palavras-chave:** El Niño; Seca; Nordeste do Brasil; Atlântico.

Instituto Nacional de Pesquisas Espaciais - INPE  
Caixa Postal 515, 12201-970 - São José dos Campos, SP, Brazil  
kane@laser.inpe.br

## INTRODUCTION

Along the coast of Peru-Ecuador in South America, there is an ocean current called Peru or Humboldt current. Hushke (1959) defined El Niño (The Child) as a warming of this ocean current, so called because it generally develops near Christmas, the birth of Jesus Christ. Quinn et al. (1978, 1987) determined the occurrence of El Niño events on the basis of the disruption of fishery, hydrological data, sea-surface temperature and rainfall along and near the Peru-Ecuador coast, defining intensities based on the positive sea-surface temperature anomalies along the coast as: Strong, in excess of 3°C; Moderate, 2.0°-3.0°C; Weak, 1.0°-2.0°C.

It is popularly believed that El Niños are associated with droughts in NE Brazil. In the past, severe droughts occurred there during the El Niño events of 1877-78, 1891, 1900, 1907, 1932, 1941, 1958, 1983. However, the number of El Niños is much larger (e.g., 52 strong, moderate and weak events during 1849-1997) and not all

were associated with droughts in NE Brazil (Kane, 1992, 1997). A detailed analysis of El Niño effects in some selected parts of Central and South America was presented in Kane (1999), where the important role of other factors not related to El Niños, notably Atlantic sea surface temperatures (SST), was emphasized. On the other hand, the mass media (press, radio, television) seems to be greatly impressed by the El Niño phenomenon alone; but the knowledgeable scientific (meteorological) community does not seem to be very enthusiastic about pointing out the limited effectiveness of El Niños and the important role of Atlantic parameters. In this communication, the El Niños are listed to show that many were ineffective in causing droughts in NE Brazil, and the expected effects (droughts) were considerably distorted by intervention from Atlantic parameters. It is hoped that the non-meteorological community would take a note of these facts and the meteorological community would put more effort (e.g., in their pronouncements in TV programs) to emphasize the role of other parameters, notably, Atlantic

parameters, so that the population is not carried away by the exaggerated expectations of the effects of El Niño, as are usually presented in the mass media.

## DATA

The El Niños are noted from the list of Quinn et al. (1978, 1987), with the addition of the recent events of 1991, 1992, 1993, and 1997-1998. For commencement and evolution of the El Niño, the SST (sea-surface temperature) anomalies at Puerto Chicama (Peru coast, 8°S, 80°W) are used. These are available since 1925 (Deser and Wallace, 1987 and private communication from Dr. Todd Mitchell). Since 1950, CPC (Climate Prediction Center of NOAA's National Centers for Environmental Prediction) Climate Diagnostic Bulletins give average monthly temperatures in four geographical regions, Nino 1+2 near the Peru-Ecuador coast (0°-10°S, 90°W-80°W), Nino 3 at (5°N-5°S, 150°W-90°W) and Nino 4 at (5°N-5°S, 160°E-150°W). Trenberth (1997) gives similar values for Nino 3.4 at (5°N-5°S, 170°W-120°W). Among these, Nino 1+2 region temperature variations match those of Puerto Chicama SST very well, except that the Puerto Chicama SST anomalies are larger by about a factor of 2. Also, the anomaly evolves and fades along the eastern Pacific almost at the same time (within a month or two) as the Puerto Chicama anomaly (1982 was an exception when anomaly at Puerto Chicama developed later, by 2-3 months). For rainfall, data for Fortaleza were obtained from SUDENE (Superintendencia do Desenvolvimento do Nordeste, Brazil) publication "Dados Pluviométricos Mensais". Also, data were used for the average of 97 stations near Fortaleza, mostly in Ceara but some in Rio Grande de Norte, Paraíba and Pernambuco (Group 3, as described in Kane and de Paula, 1993, based on Kane and Trivedi, 1988).

## RESULTS

Table 1 lists the El Niños which *were associated* with droughts (mild -; severe D) in Fortaleza and in stations in Group 3.

The following may be noted in Table 1:-

- (1) The rainfalls at Fortaleza and Group 3 are similar (only exception 1925, -, +), indicating that Fortaleza is a good representative of a fairly wide region of northeast Brazil.
- (2) The strength of the El Niño is not of much relevance, as both S and M are associated with - and D.
- (3) A detailed presentation regarding the role of El Niño *commencements* in causing droughts in NE Brazil and south Brazil is made in Kane (2000). In Table 1, all the El Niños commenced (at Puerto Chicama, Peru-Ecuador coast) in January, February, March, i.e., just before the main rainy season in NE Brazil (March, April, May) and hence, were suitable for causing droughts and did cause droughts. However, 1982 was an exception. The El Niño started much later (October) and yet, was associated with a drought in March-May, which is strange. However, 1982 was an exceptional event in that, besides other things (Quiroz, 1983), it started first in the eastern Pacific (by May 1982) and later spread eastward towards the Peru-Ecuador coast (see detailed discussion in Kane, 1999, 2000).

Table 2 shows results for El Niños which *were not associated* with droughts in NE Brazil.

The following may be noted in Table 2:-

- (1) There were 21 ineffective events (in contrast to 31 effective events). Thus, almost 40% of El Niños could be ineffective.
- (2) As in Table 1, rainfalls at Fortaleza and Group 3 are similar, except in 1918, 1923, 1966, 1969 when only Fortaleza had excess rains. This possibility should be kept in mind.
- (3) Strength of the El Niño is not of any relevance.
- (4) The El Niños of 1940 (Sep.) and 1991 (Nov.) had commencements *after* the main rainy season (March-May) of NE Brazil and hence were probably ineffective in causing droughts. But in other cases, there was no reason for failure on this count.

In years in-between the El Niño years, often La Niña (Anti-El Niño) years occur, when the SST anomalies at Puerto Chicama are negative (temperatures below average) and these are expected to be associated with excess rains in NE Brazil. Tables like Tables 1 and 2 were prepared for these La Niña events but will not

Serial No.	Year	Month of starting	Strength	Rainfall	
				Fortaleza	Group 3
1	1877		S	D	
2	1878		S	D	
3	1884		S	D	
4	1887		M	-	
5	1889		M	D	
6	1891		S	D	
7	1900		S	D	
8	1902		M	D	
9	1905		M	-	
10	1907		M	D	
11	1919		M	D	D
12	1925	Jan	S	-	+
13	1930	Mar	M	D	D
14	1931	Jan	M	D	D
15	1932	Feb	S	D	D
16	1941	Jan	S	D	D
17	1943	Jan	M	D	D
18	1948	Jan	W	-	-
19	1951	Mar	M	D	D
20	1953	Mar	M	D	D
21	1957	Feb	S	-	-
22	1958	Jan	S	D	D
23	1972	Feb	S	-	-
24	1976	Feb	M	-	-
25	1982	Oct	S	D	D
26	1983	Jan	S	D	D
27	1987	Jan	M	-	-
28	1992	Jan	S	D	
29	1993	Feb	M	D	
30	1997	Mar	S	-	
31	1998	Jan	S	D	

**Table 1** - Years of El Niños which were associated with droughts (mild -; severe D) in NE Brazil (Fortaleza and 97 stations of Group 3). Symbols S (strong), M (moderate), W (weak) indicate the strengths of the El Niños.

Serial No.	Year	Month of starting	Strength	Rainfall	
				Fortaleza	Group 3
1	1871		S	+	
2	1873		W	F	
3	1874		M	+	
4	1880		M	+	
5	1896		M	F	
6	1897		M	F	
7	1899		S	F	
8	1911		S	+	
9	1912		S	F	
10	1914		M	F	F
11	1917		S	F	F
12	1918		S	F	-
13	1923		M	+	-
14	1926	Jan	S	+	F
15	1940	Sep	S	+	F
16	1949	Feb	W	F	+
17	1965	Feb	M	+	F
18	1966	Jan	M	+	-
19	1969	Mar	W	F	-
20	1973	Jan	S	F	F
21	1991	Nov	S	+	

**Table 2** - Years of El Niños which were not associated with droughts (mild -; severe D) but were associated with floods (excess rains, mild +; severe F) in NE Brazil (Fortaleza and 97 stations of Group 3). Symbols S (strong), M (moderate), W (weak) indicate the strengths of the El Niños.

be shown here. Out of the 21 La Niña events, 12 were associated with excess rains at Fortaleza, but 9 (~40%) were not associated with excess rains. Thus, the failure rate was roughly the same as for the El Niño events.

### **ROLE OF OTHER PARAMETERS, NOTABLY, ATLANTIC PARAMETERS**

From Tables 1 and 2, it is obvious that factors other than ENSO (El Niño/Southern Oscillation) are also operative. Using the SST and wind component indices given by Hastenrath (1990), Rao et al. (1993), Servain (1991) and Servain and Lukas (1990) for the Atlantic region and the NE Brazil coast, Kane (1999) showed that for some El Niño events shown in Table 2, the droughts did not occur because the Atlantic conditions were favourable for excess rains in NE Brazil. Earlier, for NE Brazil, a considerable influence of tropical Atlantic SST was reported long ago (Markham and McLain, 1977). Other factors considered are, 700 mb circulation pattern over the North Atlantic (Namias, 1977), meridional displacement and strength of the Intertropical Convergence Zone (ITCZ) (Hastenrath and Heller, 1977), Atlantic Trade Winds (Chung, 1982), rainfall systems associated with tropical disturbances moving westward from the Atlantic towards northeast Brazil (Ramos, 1975; Yamazaki and Rao, 1977; Rao et al., 1993), and southern hemisphere cold fronts or their remains moving northward along the northeast coast of Brazil (Kousky and Chu, 1978; Kousky, 1979). There is a well defined large-scale atmospheric circulation pattern related to the sea surface temperature anomalies in the tropical Atlantic (Hastenrath and Heller, 1977; Moura and Shukla, 1981). According to Hastenrath (1990), droughts in northeast Brazil can be due an anomalously far northerly position of the intertropical convergence zone (ITCZ), reduced northeast trades and accelerated cross-equatorial flow from the southern hemisphere and anomalously warm surface waters in a zonal band across the tropical North Atlantic, contrasting with negative SST anomalies south of equator. The association with southern oscillation (SO) minima (which occur in El Niño years) may come through the displacement of the near-equatorial trough northward.

Prediction schemes based on these ideas have been formulated by Hastenrath et al. (1984), Hastenrath (1990), Hastenrath and Greischar (1993), Hastenrath and Druyan (1993) (see also Ward and Folland, 1991). Earlier, Servain and Siva (1987) had investigated the relationship between tropical Atlantic SST, wind stress and regional precipitation indices and shown that for the seasonal time scale, the northward displacement of the ITCZ was accompanied by the strengthening of the southeast trades and/or relaxation of the northeast trades which is correlated with a decrease in NE Brazil rainfall. Recently, Wainer and Soares (1997) showed that for NNE Brazil, this was true on an interdecadal time scale also. Forecast methods based on Atlantic SST conditions initiated by Ward and Folland (1991) are being used copiously now and forecasts are made by January for the coming rainy season MAM of NE Brazil. These forecasts seem to be fairly accurate (Colman et al., 1997; Harrison et al., 1997; Graham, 1997; Greischar and Hastenrath, 1997; Cavalcanti et al., 1998 a,b). As such, the great importance given to El Niño phenomenon only in the local mass media (press, radio, and television) seems to be unwarranted and could lead to disappointments and frustrations when predictions go haywire.

The 1997-1998 El Niño ended by about the middle of 1998 and soon after, a La Niña developed, which is continuing even now. Based on this fact, wet conditions would be expected in NE Brazil in the coming rainy season March-May 2000. However, this expectation could be modified, depending upon the conditions in the Atlantic. It seems that the Atlantic conditions as seen in December 1999 are also favourable for excess rains in NE Brazil and above normal precipitation is predicted by both Cavalcanti et al. (1999) and Colman and Davey (1999). If the prediction comes true, it will be a boon to thirsty NE Brazil. However, though the La Niña conditions are likely to continue in the next few months (upto June 2000), there is no guarantee that the Atlantic conditions (SST dipole) seen in December 1999 will persist in the first 6 months of 2000. If there are abrupt changes in the Atlantic conditions in Jan.-Mar., 2000, the predictions may be upset. This happened before, e.g., in 1996, when slightly below average rainfall was predicted, but the abrupt changes in Atlantic

conditions in early 1996 resulted into heavy (excess) rains (see discussions in Colman et al., 1977; Kane 1999). This is the hazard in this methodology of prediction.

## CONCLUSION

Though El Niños are popularly believed to be associated with droughts in NE Brazil, about 40% are likely to be ineffective. This is mainly because conditions in the Atlantic may be favourable for droughts in NE Brazil in some years or excess rains in some other years. In the latter case, the excess rain effects due to Atlantic conditions may reduce or even obliterate the drought effects of El Niños, and the El Niño would turn out to be ineffective. The mass media needs to be aware of this possibility, and the knowledgeable meteorological community needs to convey this possibility more emphatically to the people at large. Otherwise, disbelief in meteorological predictions will increase.

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## REFERENCES

- Cavalcanti, I. F. A., Pezzi, L. P., Nobre, P., Sampaio, G., & Camargo Jr., H., 1998a.** Climate prediction of precipitation in Brazil for the nordeste rainy season, COLA (Center for Ocean-Land-Atmospheric Studies, Calverton, Maryland, USA) Experimental Long-lead Forecast Bulletin 7, No. 1, March 1998, pp. 24-27.
- Cavalcanti, I. F. A., Pezzi, L. P., Marengo, J., Sampaio, G., & Sanches, M. B., 1998b.** Climate Prediction of precipitation over South America for DJF 1998/99 and MAM 1999, COLA (Center for Ocean-Land-Atmospheric Studies, Calverton, Maryland, USA) Experimental Long-lead Forecast Bulletin 7, No. 4, December 1998, pp. 24-27.
- Cavalcanti, I. F. A., Pezzi, Marengo, J. A., Castro, C., Sampaio, G., & Sanches, M. B., 1999.** Climate Prediction of precipitation over South America for DJF 1999/2000 and MAM 2000 using the CPTEC/COLA AGCM, COLA (Center for Ocean-Land-Atmospheric Studies, Calverton, Maryland, USA) Experimental Long-lead Forecast Bulletin 8, No. 4, December 1999, pp. 43-46.
- Chung, J. C., 1982.** Correlations between the tropical Atlantic trade winds and precipitation in NE Brazil. *J. Climatol.* **2**: 35-46.
- Colman, A., Davey, M., Harrison, M., Evans, T. & Evans, R., 1997.** Multiple Regression, Discriminant Analysis predictions of Mar-Apr-May 1997 rainfall in northeast Brazil. CPC (Climate Prediction Center) of NOAA's National Centers for Environmental Predictions, Washington D. C., Experimental Long-Lead Forecast Bulletin 6, No.1, pp.29-32.
- Colman, A., & Davey, M., 1999.** Statistical prediction of January-June 2000 rainfall in northeast Brazil using input from Multiple Regression and Discriminant analysis, COLA (Center for Ocean-Land-Atmospheric Studies, Calverton, Maryland, USA) Experimental Long-lead Forecast Bulletin 8, No. 4, December 1999, pp. 66-70.
- Deser, C. & Wallace, J. M., 1987.** El Nino events and their relation to the Southern Oscillation: 1925-1986. *J. Geophys. Res.* **92**: 14189-14196.
- Graham, N., 1997.** Prediction of precipitation in northeast Brazil for boreal spring using an atmospheric GCM with persisted SST anomalies. CPC (Climate Prediction Center) of NOAA's National Centers for Environmental Predictions, Washington D. C., Experimental Long-Lead Forecast Bulletin 6, No. 1, pp. 23-24.
- Greischar, L. & Hastenrath, S., 1997.** Multiple Regression and Discriminant Analysis to predict Mar-Apr-May-Jun 1997 rainfall in northeast Brazil. CPC (Climate Prediction Center) of NOAA's National Centers for Environmental Predictions, Washington D. C., Experimental Long-Lead Forecast Bulletin 6, No. 1, pp. 33-34.
- Harrison, M., Evans, T., Evans, R., Davey, M. & Colman, A., 1997.** A dynamical one-month lead seasonal rainfall prediction for March to May 1997 for the north-eastern area of South America. CPC (Climate Prediction Center) of NOAA's National Centers for Environmental Predictions, Washington D. C., Experimental Long-Lead Forecast Bulletin 6, No. 1, pp. 25-28.
- Hastenrath, S., 1990.** Prediction of northeast Brazil rainfall anomalies. *J. Climate* **3**: 893-904.
- Hastenrath, S. & Druyan, L., 1993.** Circulation anomaly mechanisms in the tropical Atlantic sector during the Northeast Brazil rainy season: Results

- from the GISS General Circulation model. *J. Geophys. Res.* **98**: 14917-14923.
- Hastenrath, S. & Greischar, L., 1993.** Circulation mechanisms related to Northeast Brazil rainfall anomalies. *J. Geophys. Res.* **98**: 5093-5102.
- Hastenrath, S. & Heller, L., 1977.** Dynamics of climate hazards in northeast Brazil. *Quart. J. Roy. Meteor. Soc.* **103**: 77-92.
- Hastenrath, S., Wu M-C & Chu, P-S., 1984.** Towards the monitoring and prediction of Northeast Brazil droughts. *Quart. J. Roy. Meteor. Soc.* **110**: 411-425.
- Hushke R. E., 1959.** "Glossary of meteorology". Am. Met. Soc. Boston, Mass., 638 p.
- Kane, R. P., 1992.** El Niño and La Niña events and rainfall in NE and south Brazil. *Rev. Brasileira Geof.* **10**(2): 49-59.
- Kane, R. P., 1997.** Prediction of droughts in northeast Brazil: Role of ENSO and use of periodicities. *Int. J. Climatol.* **17**: 655-665.
- Kane, R. P., 1999.** Rainfall extremes in some selected parts of central and south America: ENSO and other relationships reexamined, *Int. J. Climatol.* **19**: 423-455.
- Kane, R. P., 2000.** Relationships between El Niño timings and rainfall extremes in NE Brazil, São Paulo City and south Brazil, *Rev. Bras. Meteorologia*. (in press).
- Kane R. P. & de Paula, E. R., 1993.** Rainfall characteristics in different parts of northeast Brazil, *Rev. Bras. Geofísica*, **11**: 7-22.
- Kane, R. P. & Trivedi, N. B., 1988.** Spectral characteristics of the annual rainfall series for northeast Brazil, *Climatic Change*, **13**: 317-336.
- Kousky, V. E., 1979.** Frontal influences on Northeast Brazil. *Mon. Wea. Rev.* **107**: 1140-1153.
- Kousky, V. E. & Chu, P. S., 1978.** Fluctuations in annual rainfall for Northeast Brazil. *J. Meteor. Soc. Japan* **56**: 457-465.
- Markham, C. G. & McLain, D., 1977.** Sea surface temperature related to rain in Ceará, north-eastern Brazil. *Nature* **265**: 320-323.
- Moura, A. D. & Shukla, J., 1981.** On the dynamics of droughts in Northeast Brazil: Observations, theory and numerical experiments with a General Circulation model. *J. Atmos. Sci.* **38**: 2653-2675.
- Namias, J., 1977.** Influences of northern hemisphere general circulation on drought in Northeast Brazil. *Tellus* **24**: 336-342.
- Quinn, W. H., Zoff, D. G., Short, K. S. & Kuo Yang, R. T. W., 1978.** Historical trends and statistics of the Southern Oscillation, El Niño and Indonesian droughts. *Fish. Bull.* **76**: 663-678.
- Quinn, W. H., Neal, V. T. & Antunes de Mayolo, S. E., 1987.** El Niño occurrences over the past four and a half centuries. *J. Geophys. Res.* **92**: 14449-14461.
- Quiroz, R. S., 1983.** The climate of the "El Niño" winter of 1982-83 - A season of extraordinary climate anomalies. *Mon. Wea. Rev.* **111**: 1685-1706.
- Ramos, R. P. L., 1975.** Precipitation characteristics in the northeast Brazil dry region. *J. Geophys. Res.* **80**: 1665-1678.
- Rao, V. B., de Lima, M. C. & Franchito, S. H., 1993.** Seasonal and interannual variations of rainfall over eastern Northeast Brazil. *J. Climate* **6**: 1754-1763.
- Servain, J., 1991.** Simple climatic indices for the tropical Atlantic ocean and some applications, *J. Geophys. Res.*, **96**: 15137-15146.
- Servain, J. & Lukas, S., 1990.** "Climatic Atlas of the Tropical Atlantic Wind Stress and Sea Surface Temperature 1985-1989", Institut Francais de Recherche pour l'Exploration de la Mer, Plonzone, France, 143 pp.
- Servain, J. & Seva, M., 1987.** On relationship between tropical Atlantic sea surface temperature, wind stress and regional precipitation indices: 1964-1984. *Ocean Air Interac.* **1**: 183-190.
- Trenberth, K. E., 1997.** The definition of El Niño. *Bull. Amer. Met. Soc.*, **78**: 2771-2777.
- Wainer, I., and Soares, J., 1997.** North northeast Brazil rainfall and its decadal-scale relationship to wind stress and sea surface temperature. *Geophys. Res. Lett.* **24**: 277-280.
- Ward, M. N. & Folland, C. K., 1991.** Prediction of seasonal rainfall in the north nordeste of Brazil using eigenvectors of sea-surface temperature. *Int. J. Climatol.* **11**: 711-743.
- Yamazaki, Y. & Rao, V. B., 1977.** Tropical cloudiness over the south Atlantic Ocean. *J. Meteor. Soc. Japan* **55**: 205-207.