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14. Abstract/Notes

Rainfall data of northeast Brazil for the last 23 years (1961-1983) are examined. It is found that the drought of 1983 was extensive. In the interior dry region rainfall during the rainy season of 1983 was only 40% of the normal. The drought of this year was the worst in the past two decades. Rainfall anomalies of northeast Brazil are related to two large-scale features: 1) winter circulation of the Northern Hemisphere and 2) the Southern Oscillation. Grid point values of 700mb height of the northern Hemisphere during winter are correlated with the rainfall of northeast Brazil. Isolines of correlation coefficient showed distinct centers of positive and negative correlations. A positive center is found over Siberia during the winter months. In the February geopotential height vs. march rainfall iso-correlation map a strong negative center (significant at 99% level) is found over northeast United States. This is consistent with the earlier finding of Namais (1972). Regarding the association with the Southern Oscillations, rainfall variations in northeast Brazil seem to succeed variations in the Southern Oscillation by 2 months.

15. Remarks: Will be presented at the WMO Symposium on Tropical Droughts, Fortaleza, September, 1984.

INTERANNUAL VARIATIONS OF RAINFALL IN NORTHEAST BRAZIL AND THEIR CONNECTIONS WITH THE LARGE-SCALE FEATURES

by

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1. Introduction

Northeast (NE) Brazil is characterized by large interannual variation of rainfall. During some years severe droughts lead to intense human suffering and mass exodus. There are a few studies which describe the general climatology of this region including the rainfall characteristics (Hastenrath and Heller [3]. The rainy season is centered in March, April and May with almost no precipitation during the remaining nine months (Moura and Shukla [8]. This is related to the position of the Intertropical Convergence zone, ITCZ which has its southern most position at this time. Interannual variations in rainfall seem to be related to the interannual variations in the southward penetration of ITCZ (Hastenrath and Heller [3]). Another factor related to the interannual variations of rainfall in NE Brazil is the sea surface temperature anomaly in the Atlantic ocean. Simultaneous occurrence of warm waters in the North Atlantic and cold waters in the South Equatorial Atlantic seems to induce a meridional circulation cell with subsidence over NE Brazil (Moura and Shukla [8]. Thus, interannual variations of rainfall in NE Brazil are related to the variations in the strength of this meridional cell. Based on these and other studies, Hastenrath et al. [4] developed an elaborate statistical method of predicting rainfall anomalies in NE Brazil. The method seems to be sucessful in predicting some of the major droughts and floods.

A part from the association with the large-scale atmospheric and oceanic parameters in the Atlantic, rainfall variations in NE Brazil seem to be related to the circulation anomalies in more remote regions. Namais [9] pointed out that the intensity of cyclonic activity over Newfound land area is related to the rainfall intensity over NE Brazil. During winter the circulation characteristics in the North Atlantic ocean seem to be related to the circulation characteristics of other regions in the Northern Hemisphere (Bjerknes [1]; Wallace and Gutzler [11]). Thus, it is interesting to study the possible association between the rainfall variations in NE Brazil and the 700 mb circulation changes in the Northern Hemisphere, which is the aim of the present note. Also Walker [12] suggested that rainfall anomalies in NE Brazil are related to the Southern Oscillation (SO). Caviedes [2] and Hastenrath and Heller [3] showed that NE Brazil rainfall variations are connected to El Niño events, which are themselves related to the S.O. In this note we reexamine the association between the SO and NE rainfall using recent data.

2. Data Source

Northern Hemisphere 700mb grid point data are obtained for the winter months, December, January and February from charts published in Monthly Weather Review. We used data for 19 winters, 1963/64 through 1981/82. Precipitation data for NE Brazil are obtained from Instituto Nacional de Meteorologia of Brazil. Sea level pressure data of Darwin ($12^{o}26'S$, $130^{o}52'E$) and Easter Island ($27^{o}10'S$, $109^{o}26'W$) are obtained from 'Monthly Climate data for the World'.

3. Results and Discussion

Fig. 1 shows the normalized deviation of rainfall during the rainy season March, April and May over NE Brazil for the period 1964 through 1983. To construct this figure, 20 raingawge stations in the northern part of NE Brazil are used. Initially, means and

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standard deviations for each station are determined. Then, the departures of individual years are expressed in terms of the standard deviation producing normalized departures. All station averages of normalized departures are shown in Fig. 1. It can be seem from Fig. 1 that 1974 was a heavy rainfall year and 1983 was an intense drought year. In order to obtain the spatial distribution of rainfall for the year 1983, the deviation for the principal rainy season from the normal is expressed as

$$D = \frac{P_i - \overline{P}}{\overline{P}} \times 100,$$

where D is the normalized deviation expressed in %, $\overline{P}$ is the normal, P_i is the precipitation for March, April and May of 1983. The normalized deviations are obtained for 51 stations and isolines of these deviations are shown in Fig. 2. It can be seen from Fig. 2 that the drought of this year was extensive and in the interior dry region rainfall was only 40% of the normal. Also from Fig. 1 it can be seen that NE Brazil has been under the influence of a dry spell for the past 5 years except for some slight relief in 1981. Even during 1981 only March rainfall was higher than the normal with April and May rainfall being much below normal.

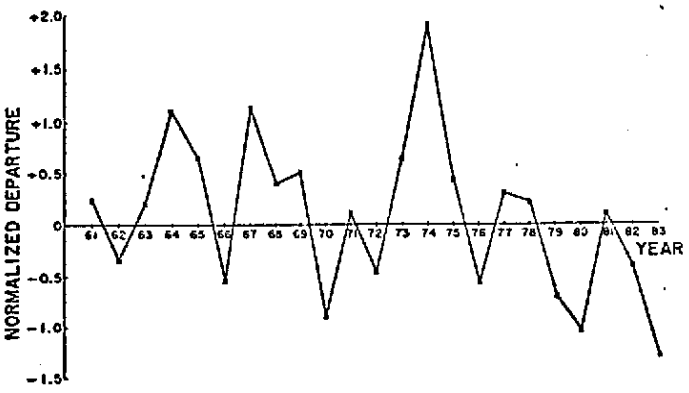

Fig. 1 Normalized deviation of rainfall based on 20 stations in NE Brazil.

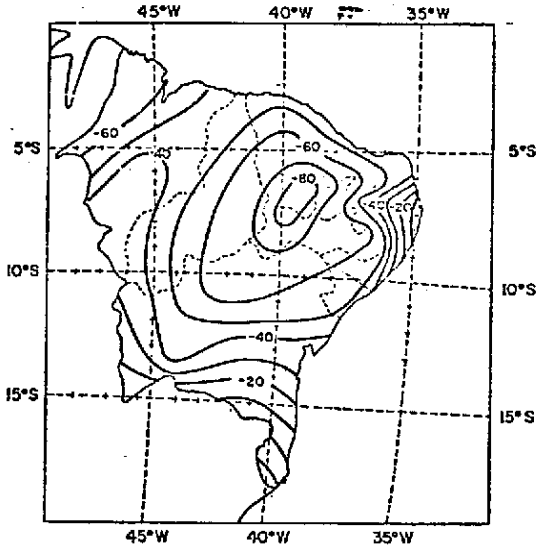

Fig. 2 - Normalized deviation of rainfall for March, April and May of 1983.

Fig. 3 shows the isolines of correlation coefficient (inpercent) between March rainfall of NE Brazil and the grid point data of 700 mb December geopotential height of Northern Hemisphere. Distinct centers of positive and negative correlation can be seen in the Figure. Positive centers are seen over SW Europe and over Siberia. Negative centers are seen over Greenland/Iceland region, NW Pacific and near about Japan. A region of negative correlation is also seen over North Africa.

Fig. 4 shows the isolines of correlation coefficient between March rainfall and January geopotential height. Positive centers over SW Europe and Siberia could be seen in this map also, with increased values. A new positive center is seen over SE United States. Negative regions or centers are found over Greenland, Gulf of Alaska and over NW Africa. Positive centers over Siberia and Western Europe and negative center over NW Africa are significant at 99% level.

Fig. 5 shows the iso-correlation map for February geopotential height vs. March rainfall. In this map a strong negative center (significant at 99% level) is found over NE United States.This iso-ocorrelation map shows interesting patterns. Particularly the pattern starting with a negative center over NE US and ending with a positive center around 160°E is strongly reminiscent of the Pacific/North American pattern noted by Wallace and Gutzler [11], although the spatial scale is not quite the same. The negative center over NE US can be understood in terms of an explanation given by Hastenrath et al [4]. Deepening of low pressure here is favorable for strengthening of subtropical high in the North Atlantic. This in turn is favorable for a more southerly location of Quasi-permanent circulation features over tropical Atlantic such as ITCZ and higher rainfall over NE Brazil.

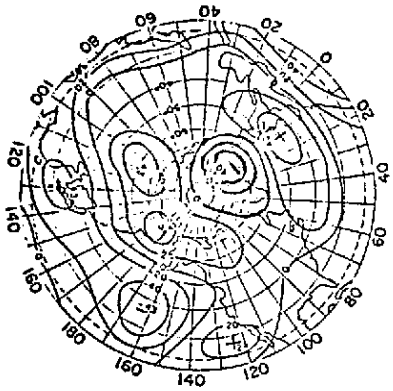

Fig. 3

Fig. 4

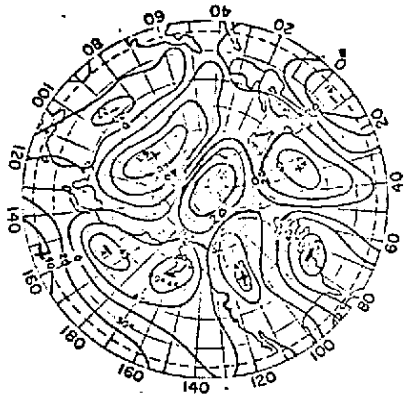

Fig. 5

Isocorrelation maps between 700 mb geopotential height and rainfall over NE Brazil. Fig. 3. Dec height vs. March rainfall.Fig. 4. Jan height vs. March rainfall. Fig. 5 Feb height vs. March rainfall.

It is known that the circulation variation during the winter in the N.H is related to the Southern Oscillation (SO) (Bjerknes, [1];Horel and Wallace, [5]) and the rainfall variations in NE Brazil are also related to the SO (Walker, [12] and others). Table 1 shows the correlation coefficient between the SO index and NE Brazil rainfall for March, April and May. Here the Sea Level pressure of Easter Island minus Darwin sea level pressure is taken as the S.O index. To calculate these correlation coeficients 23 years data (1961-1983) are used. From the Table it can be seen that the highest correlation is found between January SO index and March rainfall, February SO index and April rainfall and March SO index and May rainfall. All these coefficients are significant at 95% level (marked * in the Table) and the correlation between February SO and April rainfall is significant at 99% level (marked **).

The association between the SO and rainfall over NE Brazil may be related to the east-west walker circulation in such a way that NE Brazil could come under the influence of sinking or raising motion favoring lower or higher rainfall (Stoeckenius [10], Kousky et al. [6]). The association may also be related through El Niño mechanism, which is know to influence the Northern Hemisphere winter circulation in the Atlantic Sector (in addition to other regions) which in turn is known to modify the rainfall characteristics of NE Brazil. In a recent theoretical study Lau and Lim [7] showed that a heat source at the equator in western Pacific (presumably formed during El Niño event) could generate a Pacific - North American pattern, in a way similar to the pattern noted earlier in the correlation maps. The relevance of the negative center over NE US in this pattern for NE Brazil rainfall is already pointed out earlier in this section.

Table 1. Correlation Coefficient between rainfall over NE Brazil and the Southern Oscillation

S.O INDEX	RAINFALL OVER NE BRAZIL		
	MARCH	APRIL	MAY
September	0.01	0.26	0.15
October	0.29	-0.1	-0.19
November	0.26	0.28	0.27
December	0.21	0.23	0.14
January	0.47*	0.28	0.22
February	0.27	0.56**	0.16
March	0.26	0.44	0.46*
April	-	0.33	0.14
May	-	-	-0.05

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