Annual variation of rainfall over Brazil and atmospheric circulation over South America

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Abstract

A large region in Central Brazil is characterized by summer rainfall and winter dry conditions. During the six-month period SONDJF, this region receives 70% or more of its annual rainfall. It is suggested that the Amazon basin is the principal source of moisture for this region.

1 - Introduction

Most of the tropical regions except for a few places such as western Amazon Basin, are characterized by strong annual variation of rainfall, with heavy rainfall in summer and scanty rainfall in winter. Annual variation in certain parts of the tropics and subtropics is known as monsoon. A monsoon is associated with a reversal of 180^{o} in the surface winds from winter to summer (Fein and Stephens 1987).

South America is not usually considered to experience a monsoon regime (Ramage, 1971). A seasonal reversal of 180 in the surface winds is not observed.However, many of the features which characterize a monsoon regime are observed there also during the austral summer (December, January and February).

The purpose of the present study is to examine the annual variation of rainfall over brazil and atmospheric circulation over South America.

2 - Data sources

To depict the annual variation of rainfall over Brazil we used the same network of rain gauge stations as in a previous study (Rao and Hada, 1990). Fig.1 of that paper gives the station location. As in the previous study we used the rainfall data for the period 1958 trough 1978. We also used the surface dew point temperature data for Brasilia (15^{o} 51'S, 47^{o} 56'W) and Manaus (3^{o} 8'S, 60^{o} 1'W). These data were provided by the Departamento Nacional de Meteorologia of Brazil.

3 - Results

Figure.1a shows the isolines of percentage contribution of the rainfall for the three month period December, January and February (DJF) to the annual rainfall. Similarly figures.1b, 1c and 1d show respectively the percentage contribution of MAM, JJA and SON to the annual rainfall.

Several interesting features are evident in these figures. In southern Brazil rainfall is almost uniformly distributed in all the four seasons, with a contribution of around 25% in each of the three-month periods. To the north of this region, there is a large area over which the percentage in DJF is around 45% or more. In SON the percentage contribution is around 25% or more. Thus during the six month austral summer period SON and DJF the percentage contribution to the rainfall is 70% or more. Thus the remaining 6-month winter period the rainfall is 30% or less of annual total. This region has annual rainfall distribution such that summer is rainy and the winter is dry, which is typical of a monsoonal regime.

Examination of Figures.1b, 1c and 1d show that Brazil can be divided approximately into five regions: 1- Southern Brazil with well distributed rainfall throught the year, 2- a large central region with a wet summer and dry winter regime, 3- Northwest region in which the rainfall is well distributed throughout the year, 4- Northern NE Brazil with rainfall season in MAM and 5- Eastern NE Brazil with the principal rainy season in winter.

Figure.2a shows daily values of the surface dew point (^{o}C) at Brasilia for 12 UTC. The smoothed line is the running mean for 11 days. the stars below each dew point value denote the occurence of precipitation at Brasilia. The horizontal line is the yearly mean value. Note that there is a rapid transition from dry conditions without much rainfall up to the end of September to a wet air mass in which precipitation is frequent. the wet conditions remain up to the end of April and then there is a gradual return to dry conditions without much rainfall.

In order to see how the variations of dew points are in the northwest region we plotted the dew points at Manaus (Fig.2b). The characteristics of this figure are very different from those shown at Brasilia (Fig.2a). As expected the yearly average value at Manaus is much higher than the yearly average value at Brasilia. Unlike what is seen for Brasilia, there is no clear indication of dry and wet periods, except for a slight decrease of dew points and rainfall in July and August.

From the analysis of dew point temperatures it can be inferred that the central parts of Brazil represented by Brasilia, have a clear variation of atmospheric regime with a dry epoch without much rainfall from April through September and a wet period characterized by high humidity and rainfall during the remaining months of the year. What features of atmospheric circulation are responsible for the change from the dry period at Brasilia to the wet period?

Figure.3 adapted from Figure 8a of Chen (1985), shows the vertically integrated water vapor transport vector field for the total flow. Here we discuss the characteristics of water vapor transport over south Atlantic and South America. The most relevant feature of this figure for the present study is the southeastward transport of water vapor from Amazon basin and the convergence of water vapor into central South America. Thus the increase of humidity over central parts of Brazil noted earlier during summer (Figure.2a) is due to the incursion of moisture from the Amazon basin.

4 - Summary and concluding remarks

The annual variation of rainfall over Brazil is discussed. There is a large region in central Brazil which is characterized by summer rainfall. During the six-month period SONDJF this region receives 70% or more of the annual rainfall. Thus, the rainfall regime is monsoon like. A careful analysis of the vertically integrated water vapor transport given by Chen (1985) (over South America) suggests that this increase of humidity over Brasilia is associated with the incursion of moisture from the Amazon region.

References

Chen, T.C. 1985: Global water vapor flux and maintenance during FGGE. Mon. Wea. Rev. 113, 1801-1819.

Fein, J. and P.L. Stephens. 1987. Monsoons. Wiley interscience publication. New York.

Ramage, C.S. 1971. Monsoon Meteorology. New York. Academic Press. 296pp.

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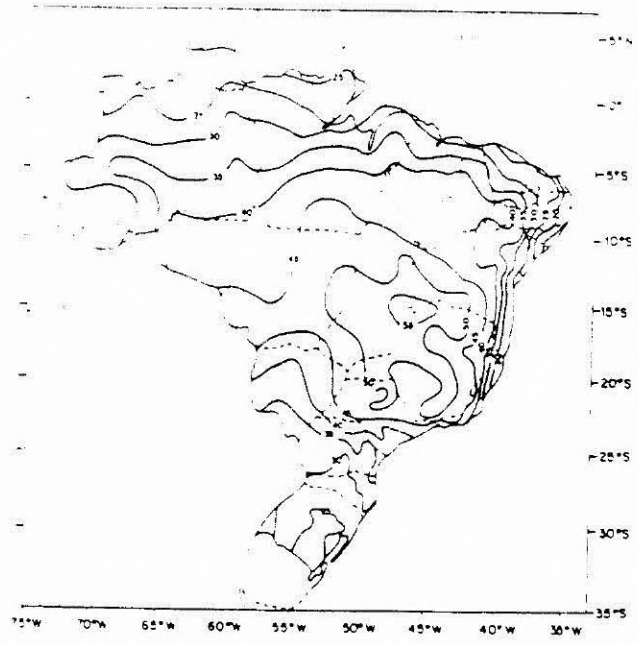
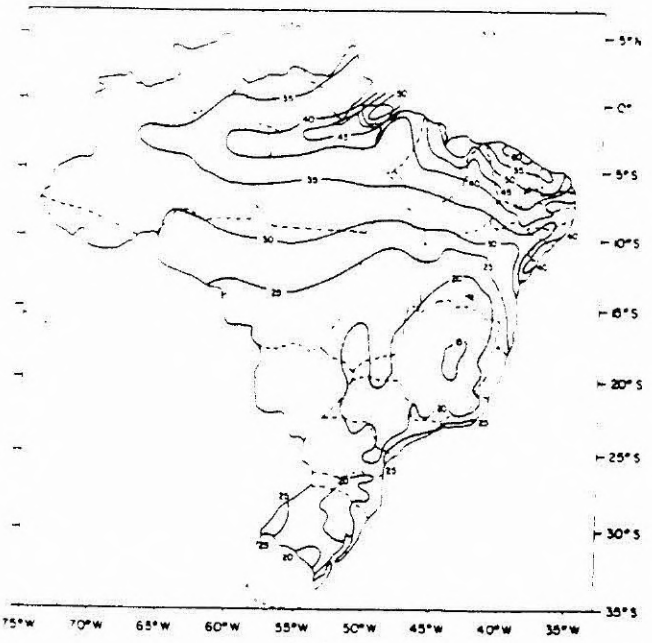
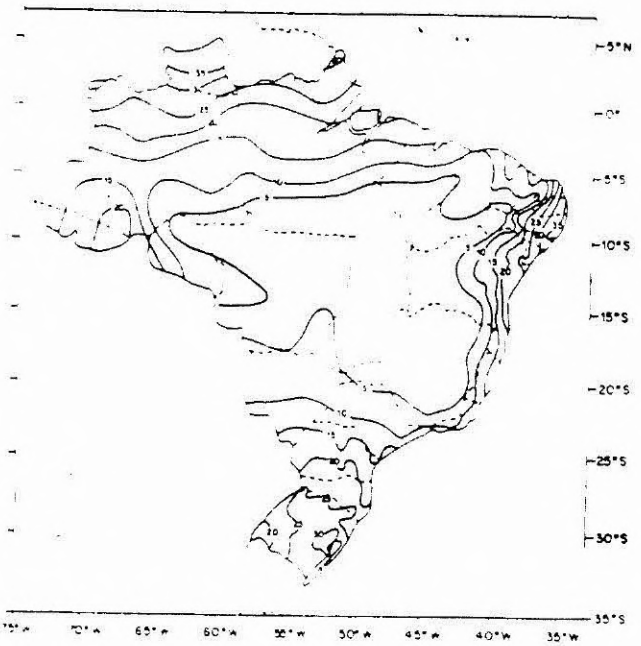

5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
35°S
75°W
70°W
65°W
60°W
55°W
50°W
45°W
40°W
35°W

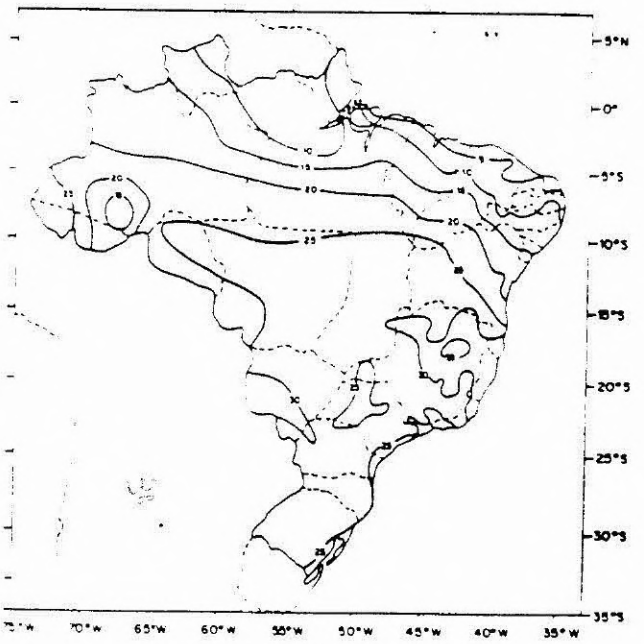
(a)


5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
35°S
75°W
70°W
65°W
60°W
55°W
50°W
45°W
40°W
35°W

(b)

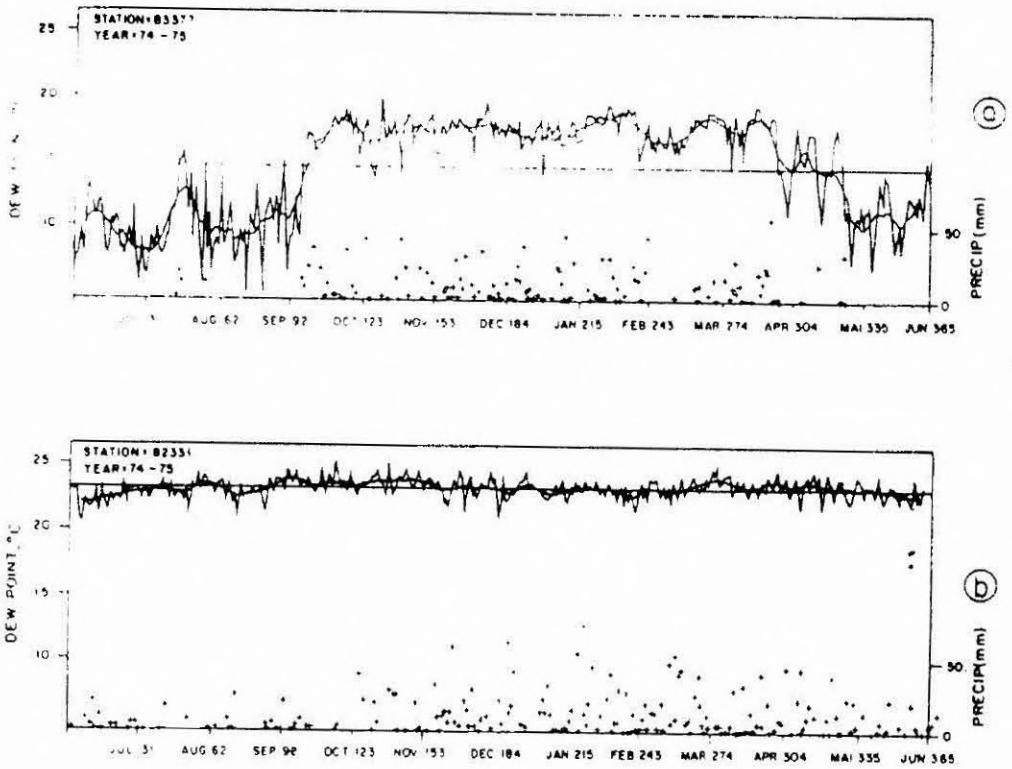

5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
35°S

(c)


5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
35°S
70°W
65°W
60°W
55°W
50°W
45°W
40°W
35°W

(d)

FIG. 1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YEAR: 74 – 75
DEW POINT °C
PRECIP (mm)
AUG 62
SEP 92
OCT 123
NOV 153
DEC 184
JAN 215
FEB 243
MAR 274
APR 304
MAI 335
JUN 365
a
STATION: 82353
YEAR: 74 – 75
DEW POINT °C
PRECIP (mm)
JUL 31
AUG 62
SEP 92
OCT 123
NOV 153
DEC 184
JAN 215
FEB 243
MAR 274
APR 304
MAI 335
JUN 365
b

FIG 2

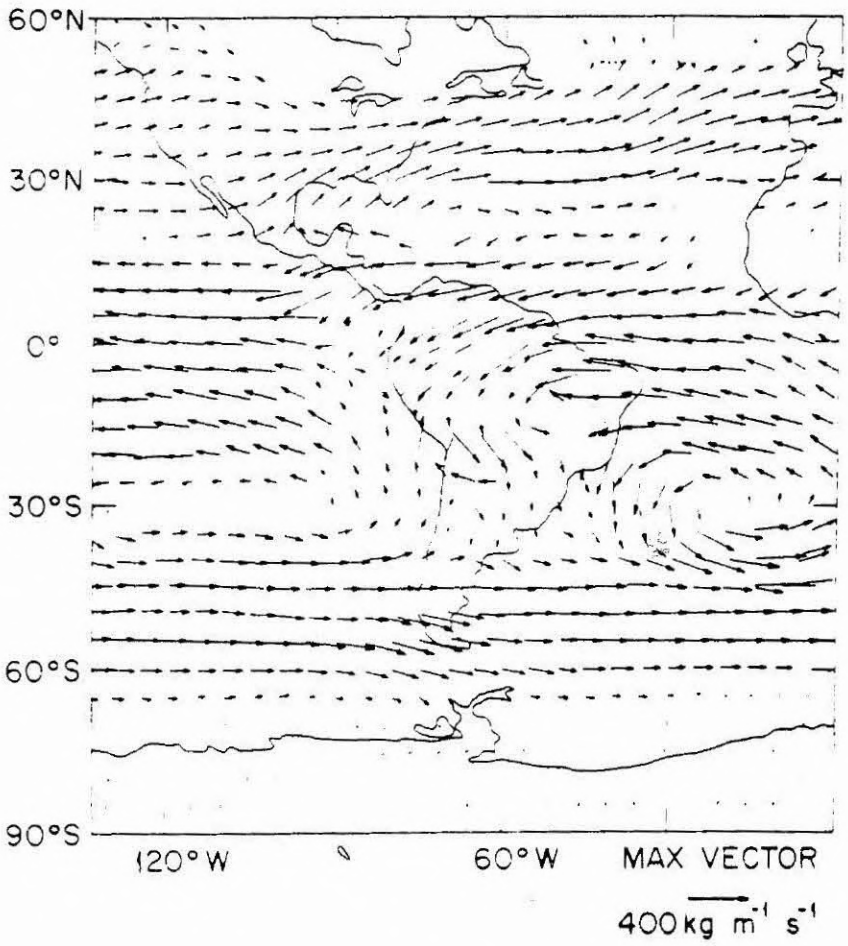
60°N
30°N
0°
30°S
60°S
90°S
120° W
60° W
MAX VECTOR
400 kg m⁻¹ s⁻¹

FIG 3