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MERIDIONAL PENETRATION OF FRONTAL SYSTEMS IN SOUTH AMERICA AND ITS RELATION TO ORGANIZED CONVECTION IN THE AMAZON

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14. Abstract/Notes

The penetration of mid-latitude frontal systems into the tropics and its relation to the enhancement of convective activity over the Amazon was investigated. A five-year climatology of frontal activity in South America based on GOES satellite imagery was developed. It showed a large number of episodes in which NW-SE oriented convective cloud bands over the continent seemed to be associated and moved with the frontal systems to the east for the austral spring, summer and autumn. During winter frontal systems rarely organize convection over the Amazon. The preferred position of the frontal systems and associated convective cloud bands to the west-northwest aid in explaining the observed relative annual precipitation maximum extending from western Amazon to southeastern Brazil and into the South Atlantic. A synoptic case study for a frontal passage in the period 29 April - 06 May 1980 indicated that the strengthening and progression to the east-northeast of the upper-level trough associated with the frontal system may be related to the enhancement of convective activity over Central Brazil and the Amazon. It was observed for this case a north-easterly shift of the band of maximum convective precipitation from western Brazil to eastern Amazon, following the progression of the frontal system.

15. Remarks To be presented at the 16th Conference on Hurricanes and Tropical Meteorology, Houston, Texas, May 1985.

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of 20°S seldom organize convection in the Amazon during winter. This is probably due to large-scale subsidence over most of subtropical South America during winter months, which would inhibit convection. It is remarkable the large number of convection days for summer, spring an autumn, primarily for the FS at the latitudes between 35°S and 20°S and the associated convective clouds extending from southeastern Brazil towards southwestern Amazon.

Maps of annual precipitation for South America show a broad region of relative maximum precipitation from southwestern Amazon through Central Brazil to Southeast Brazil and into the South Atlantic (Jaeger, 1976). This broad maximum is consistent with the preferred mean position of FS and the associated convective cloud bands to the west-northwest as shown in Column B2. There is still a significant number of convection days for FS moving north of 20°S which organize convection in central and eastern Amazon (Column B3).

2.2 Synoptic Case Study

We have analysed in greater detail several cases of enhanced convection activity over the Amazon, but due to space restriction in this report only one case for the period 29 April-05 May 1980 is included here.

In Figure 1 we show the mean position of the FS at 18:00 GMT for the analysed period. We see that the FS moved from 35°S in Uruguay on 29 April northeastward and left the continent on 05 May well into the tropics in Northeast Brazil (at about 12°S). There was an extensive convective cloud band associated with this FS to the northwest of it over the continent. This NW-SE oriented organized convective cloud band progressed from a position near and parallel to the Andes Cordillera on 29 April towards central and eastern Amazon accompanying the progression of the FS. The progression of region of enhanced convection is illustrated in Figure 2 that shows fraction of the total monthly precipitation for several station in central and northern Brazil for two periods: 29 April-02 May (Fig. 2A) and 03-06 May (Fig. 2B). Comparing Figure 2A to Figure 2B we see that the band of maximum precipitation moved from the west-northwest towards the east-northeast. It is remarkable that many stations received most of their monthly precipitation from a single FS-enhanced convective activity episode. It was generally observed that the enhanced convective activity was related to the intensification of the upper level trough accompanying the FS and also that the decaying phase of the convective activity seemed to bear some relation to the weakening of the upper-level trough.

The physical understanding of the dynamics of the interlatitudinal interactions of mid-latitude FS and enhanced convective activity in the Amazon is still quite incomplete and it is the object of a forthcoming paper.

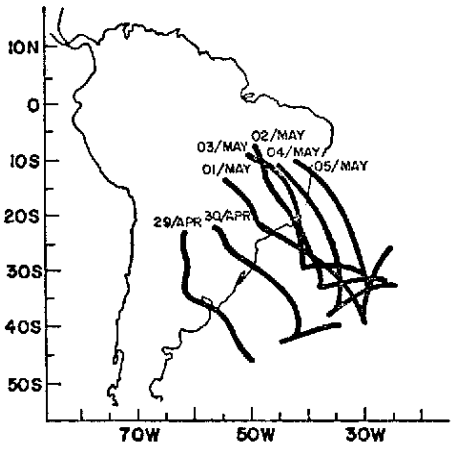

Fig. 1 - Position of the frontal system at 18:00 GMT from 02 April 1980 to 05 May 1980.

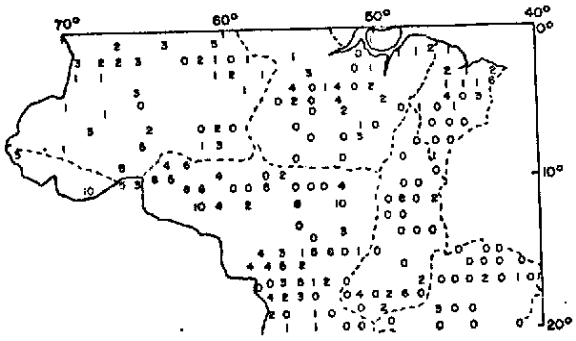

Fig. 2A - Station values of precipitation as a percentage of the station's total monthly precipitation for the period 29 April-02 May 1980. Numbers read as follow: 0 → no rainfall; 1 → total rainfall for the period between 1% and 10% of the total for the month; 2 → between 11% and 20%; ...; 10 between 91% and 100%.

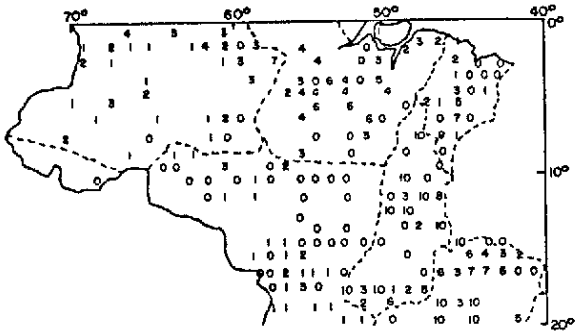

Fig. 2B - Same as Figure 2A but for the period 03-06 May 1980.

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MERIDIONAL PENETRATION OF FRONTAL SYSTEMS IN SOUTH AMERICA AND ITS RELATION TO ORGANIZED CONVECTION IN THE AMAZON

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1. INTRODUCTION

It has been widely recognized that condensational heating over the Amazon acts as an important heat source for the atmosphere. It is possible that fluctuations in the intensity and position of this heat source play a significant role in determining tropical and extratropical weather and climate. A first step towards understanding these fluctuations is to study the mechanisms which cause precipitation in that region. By and large, there are three principal rain-producing mechanisms: 1) small- and meso-scale convection (diurnal cumulonimbus clusters) resulting from solar heating of the ground and from large-scale conditions favorable to moisture convergence at the lower levels; 2) westward-moving line disturbances originating along the Atlantic coast probably due to the sea-breeze front, and 3) meso- and large-scale convective bursts associated with the penetration of frontal systems from mid-latitudes into the tropics. In this study we will report some preliminary results of an ongoing research about the third mechanism, i.e., that the penetration of mid-latitude frontal systems (thereafter referred to as FS) into low-latitudes has a pronounced effect in enhancing convection over tropical South America as originally observed by Kousky (1979), Kousky and Ferreira (1981) and Virji and Kousky (1983).

Data for this study have been obtained from several sources including the U.S. National Meteorological Center analyses, GOES satellite imagery from Brazil's Instituto de Pesquisas Espaciais and daily rainfall from Brazil's Departamento Nacional de Águas e Energia Elétrica.

2. RESULTS

2.1 Climatology

Table 1 shows a climatology of frontal activity over South America as revealed by GOES satellite imagery. We consider only those systems which have a significant cloud pattern. Column A shows the number of FS reaching a given latitudinal band along the south american Atlantic coast (see Figure 1 as an example of one such a FS). We observed that the number of FS reaching 35°-40°S (Column A1) is highest during austral winter, as it would be expected from baroclinic instability theory, but there is also a relatively high frequency of fronts for the other seasons including summer. To the author's knowledge the dynamics of propagation and energy sources of such FS for summer months, sometimes moving deeply into the tropics, is not yet well-understood. Fewer but still a significant number of FS move up to 20°S (Column A2) primarily during winter and autumn. A reduced number of FS move north of 20°S (Column A3) and some of them reach Northeast Brazil in the tropics, being responsible for some of the rain experienced by that drought-prone region (Kousky, 1979).

Table 1: Five-year climatology of frontal activity over South America as revealed by GOES satellite imagery for the period January 1977 - December 1981.

Months	A Number of fronts			B Number of days with organized continental convection		
	A1	A2	A3	B1	B2	B3
Jan	34*	29	8	23*	77	29
Feb	42	18	7	33	53	29
Mar	34	29	4	9	78	18
Apr	39	23	9	6	66	21
May	61	38	11	3	40	13
Jun	49	32	19	0	15	1
Jul	66	40	14	0	16	0
Aug	56	37	11	2	26	5
Sept	42	24	12	6	59	22
Oct	41	35	18	13	61	26
Nov	38	36	14	3	90	28
Dec	42	29	10	24	85	25
TOTAL	544	370	137	122	666	237

* 4 years only.

Of greater interest to the objectives of this study is Column B showing the number of organized continental convection days for NW-SE oriented convective cloud bands associated with the FS. We observe that during winter months FS located in 35°-40°S (Column B1) rarely organize convection to the northwest parallel to the Andes Cordillera over the continent. Also the FS north

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