1. Publication Nº	2. Version	3. Date	5. Distribution
INPE-2729-PRE/311		May, 1983	☐ Internal ☒ External ☐ Restricted
4. Origin: DME/DPM	Program: METBA		

6. Key words - selected by the author(s)

UPPER TROPOSPHERIC LOWS, FORMATION AND BEHAVIOR
TROPICAL CONVECTION, ORGANIZED

7. U.D.C.: *551.515.2:551.510.52(261.5)*

8. Title *INPE-2729-PRE/311*

LOW LATITUDE UPPER TROPOSPHERIC CYCLONIC VORTICES IN THE SOUTH ATLANTIC: THEIR ORIGIN, CHARACTERISTICS AND EFFECTS ON TROPICAL CONVECTION OVER EASTERN BRAZIL

10. Nº of pages: *04*

11. Last page: *03*

12. Revised by

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14. Abstract/Notes

The occurrence of upper tropospheric cyclonic vortices in the low latitude region of South America and eastern Brazil is related to characteristics of the upstream flow. These vortices form primarily during the southern summer months when the upper tropospheric flow over South America is strongly anticyclonic. Individual systems form or intensify generally 12-24 hours after the amplification of an upstream ridge. Although the displacement of these vortices is generally erratic there is a tendency for the low latitude (10-15S) systems to move westward. These greatly affect the distribution and intensity of convection over eastern Brazil.

15. Remarks *Will be presented at the First International Conference on Southern Hemisphere Meteorology, July 31 - August 6, São José dos Campos, 1983.*

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LOW LATITUDE UPPER TROPOSPHERIC CYCLONIC VORTICES IN THE SOUTH ATLANTIC: THEIR ORIGIN, CHARACTERISTICS AND EFFECTS ON TROPICAL CONVECTION OVER EASTERN BRAZIL

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1. INTRODUCTION

Several authors have investigated the seasonal and interannual variability in rainfall in Northeast Brazil in an attempt to better understand the dynamics of the severe droughts and floods which affect this region (e. g. Namias, 1972; Hastenrath and Heller, 1977; Markham and McLain, 1977; Moura and Shukla, 1981). These studies used either monthly or seasonal quantities. On the other hand, rainfall in the semi-arid interior of Northeast Brazil occurs over relatively short periods and in a relatively small number of events (Ramos, 1975): Transitory systems such as easterly waves and cloud clusters (Ramos, 1975), cold fronts (Ratisbona, 1976; Kousky, 1979) and upper tropospheric cyclonic vortices (Dean, 1971; Aragão, 1975; Kousky and Gan, 1981), have been shown to be the primary causes for the rainfall events.

In this paper we extend the work of Kousky and Gan (1981) in regards to the upper tropospheric cyclonic vortices. Our emphasis will be on the synoptic events which lead to vortex formation and on the distribution of rainfall in relation to the vortices.

2. ANALYSIS METHOD

Streamline and vorticity analyses have been produced for several cases in which upper tropospheric cyclonic vortices formed at low latitudes over the South Atlantic. Each vortex studied was characterized by a well defined cloud signature. The synoptic events during the life cycles of the vortices were analyzed to determine general features.

3. RESULTS

a. Vortex climatology (1974-1981)

We consider here only those cyclonic vortices which originate in the South Atlantic or over eastern Brazil and have a significant cloud pattern. As a basis for our climatological analysis we referred to microfilm copies of geostationary satellite images which were obtained from the World Data Center, Asheville, North Carolina.

MONTH	Nº	VORTEX DAYS
JAN	18	93
FEB	15	82
MAR	8	53
APR	5	10
MAY	-	1
JUN	-	-
JUL	-	-
AUG	-	-
SEP	2	5
OCT	1	3
NOV	11	42
DEC	10	68
TOTAL	70	357

Table 1. *The number of "wet" upper tropospheric cyclonic vortices and the number of vortex days for systems which formed in the South Atlantic during the period September 1974 - August 1981.*

Table 1 shows the number of cyclonic vortices as well as the number of vortex days (number of days with a vortex present) as a function of month. It is readily apparent that these systems are most frequent during the southern summer with peak activity occurring in January. Comparing Table 1 with Fig. 1 it is evident that there is a strong positive correlation between the seasonality in the frequency of the cyclonic vortices and the seasonal cycle in the meridional component of the upper tropospheric wind over the South American region.

During the summer months a strong upper tropospheric anticyclone is present in the area of Bolivia while during the winter months the flow is practically zonal.

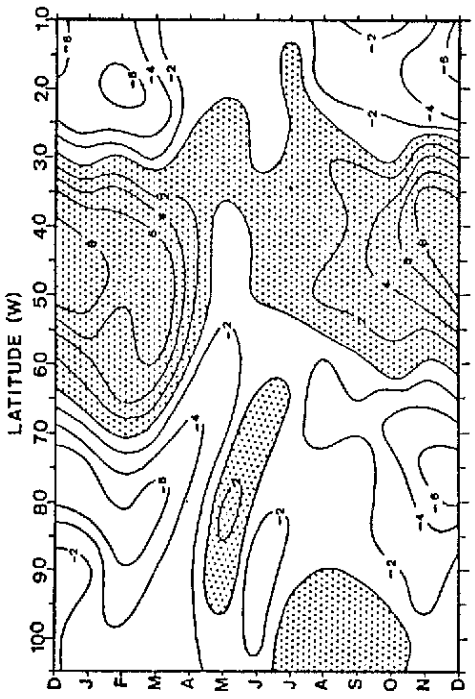

Fig. 1 – Monthly means (1975-1979) versus longitude of the 200 mb meridional wind component at 15°S. Analysis interval is 2 ms^{-1}. Positive values (southerly winds) are shaded.

b) Vortex formation

Since the seasonal behavior of the vortices is closely related to the seasonal intensity of the South American upper tropospheric anticyclone, it seems reasonable to assume that short term variations in the intensity of this anticyclone be related to short term variations in cyclonic vortex intensity . The analyses of the 200 mb vertical component of relative vorticity indicate that prior to the increase in cyclonic vorticity over low latitudes in the South Atlantic a transitory mid-latitude ridge enters southern and southeastern Brazil and intensifies. This ridge, which merges with the anticyclonic circulation over Bolivia, frequently extends from Bolivia southeastward over the South Atlantic. Within 24 hours after the ridge intensifies over Brazil cyclonic relative vorticity begins to increase at low latitudes in the South Atlantic. The upper tropospheric ridge is generally situated very close to a vigorous cloud band associated with an extratropical frontal system. The approach of the mid-latitude cold front serves to organize and enhance convection over a large portion of tropical and subtropical South America. This enhanced convection conceivably contributes, through the release of latent heat, to the intensification of the upper level ridge and therefore to the eventual formation of the low latitude upper tropospheric cyclonic vortex.

c. Vortex effects on rainfall

As evident in satellite imagery (see e. g. Kousky and Gan, 1981), the upper tropospheric cyclonic vortex is characterized by sinking motion within its circulation. Over continental regions diurnal heating is often sufficiently strong to overcome this sinking motion to produce large convective cells in the vicinity of the vortex center. Along the perifery of the cyclonic circualtion, over continental areas, enhanced convection often occurs. The associated diabatic heating would tend to maintain a strong horizontal thermal gradient.

4. CONCLUSION

The occurrence of upper tropospheric cyclonic vortices in the low latitude region of the South America and eastern Brazil is related to characteristics of the upstream flow. These vortices form primarily during the southern summer months when the upper tropospheric flow over South America is strongly anticyclonic. Individual systems form or intensify generally 12-24 hours after the amplification of an upstream ridge. Although the displacement of these vortices is generally erratic there is a tendency for the low latitude (10-15°S) systems to move westward. These greatly affect the distribution and intensity of convection over eastern Brazil.

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