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14. Abstract/Notes

An analysis of the monthly departure of the relative vorticity and wind fields over the globe was performed for the period from 1963 to 1980. Planetary-scale wavelike (teleconnection) patterns were observed in the vorticity and wind deviation fields extending from subtropical North Atlantic through the North Pole to eastern Siberia for years of droughts and excessive rainfall over Northeast Brazil (Nordeste). These patterns are sharpest in December-January. Of major interest is the phase coherence of the wavelike patterns and the precipitation anomalies of Nordeste, that is, the phase of the patterns is reversed from very dry to very wet years. Such phase coherence and also the emergence and persistance of the wavelike pattern several months previously to the rainy season in Nordeste (March--May), seems to indicate there might be some predictive potential in these configurations.

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

LARGE-SCALE CIRCULATION ANOMALIES AND PREDICTION OF NORTHEAST BRAZIL DROUGHTS

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1. INTRODUCTION

There has been a growing interest in understanding and predicting tropical climatic variability and precipitation anomalies, such as the recurrent droughts or heavy rainfall years in Northeast Brazil (Nordeste). Attempts to predict droughts in Nordeste have been either purely statistical or based on dynamical-statistical formulations. Under the former are the methods based on spectral properties of precipitation time series (de Mesquita and Morettin, 1984). On the other hand, the dynamical-statistical methods (Walker, 1928; Hastenrath et al., 1984) use multiple regression analyses to find predictors of Nordeste rainfall among several meteorological and oceanographic parameters preceding the rainy season.

Namias (1972) has shown some evidences relating precipitation over Nordeste to cyclonic activity over Greenland-New Foundland area during the Northern Hemisphere winter and spring. He suggested that strong blockings over North America and North Atlantic are usually associated with devastating droughts over Nordeste.

The rainy season in the northern part of Nordeste is centered in March-April and is related to the southernmost migration of the ITCZ cloudiness band over western Atlantic, i. e., when the oceanic ITCZ is located in the vicinity of Nordeste. Nobre et al. (1985) has observed the occurrence of a planetary-scale wave-like pattern linking North Atlantic and East Asia (thereafter referred to as NAEA pattern) for years of large precipitation anomalies over Nordeste. It occurs in upper-and lower-level vorticity and wind deviation fields during Northern Hemisphere winter. For the analysed period such a pattern presented a phase reversal when years of extreme drought are compared to years of excessive rainfall.

In this work we intend to study the feasibility of using this very phase reversal of large-scale circulation anomalies towards developing a drought forecasting sheme for Nordeste.

2. DATA ANALYSIS

The data used consisted of Northern Hemisphere monthly grid-point wind data obtained from National Meteorological Center (USA) for the period September 1963-December 1980. Annual precipitation diagrams for Nordeste were obtained from de Brito (1984) and Hastenrath et al. (1984). Means of wind for the period 1963-1980 for each month were calculated. The monthly wind and vorticity deviations from the mean for October to May (rainy season in Nordeste) were analysed every year. The analyses were carried out only for the 200mb level because the wind deviations show an essentially equivalent barotropic vertical structure (Nobre et al., 1985; Hoskins and Karoly, 1981).

3. RESULTS

From the analyses two basic wave trains emerge: one corresponds to the PNA (Pacific-North America pattern) of Wallace and Gutzler (1981) study. This pattern shows only a weak phase relationship with precipitation anomalies in Nordeste. The other starts in middle North Atlantic, going through the polar region up to East Asia (NAEA) with a branch towards Northern Africa/Red sea (Figures 1 and 2).

The reference pattern NAEA(0), where the value within the parentheses represents an arbitrary phase assigned to the pattern, is taken as the mean wind deviations found for drought years in Nordeste as indicated in Figure 1. This figure shows the composite mean circulation deviation at 200mb for the months of Dec/69, Nov/71, Dec/75, Jan/79 and Jan/80, preceding the occurrence of drought in Nordeste. This pattern was observed in Dec/66, Dec/69, Nov/71, Dec/73, Dec/75, Jan/79 and Jan/80. Figure 2 is the counterpart of Figure 1 but for the months of Dec/63, Jan/71, Dec/72, Jan/74, Dec/76 and Dec/77 preceding the occurrence of heavy precipitation in Nordeste. It illustrates the NAEA(π) pattern which was observed in Nov/63 through Feb/64, Dec/70, Jan/71, Dec/72, Jan/73, Jan-Feb/74, Nov/74, Feb/75, Dec/76, Dec/77, Dec/78, Dec/79 and Nov/80.

Figure 3 displays the mean normalized precipitation deviations for 32 stations in Nordeste from 1963 through 1978 (Hastenrath et al., 1984) and for 20 stations from 1979 through 1981 (de Brito, 1984). The symbols 0 and π indicate respectively the years when NAEA patterns approximately coincide whith those in Figure 1 and when the patterns are in reverse phase. Years without either symbol are those for which the pattern was absent.

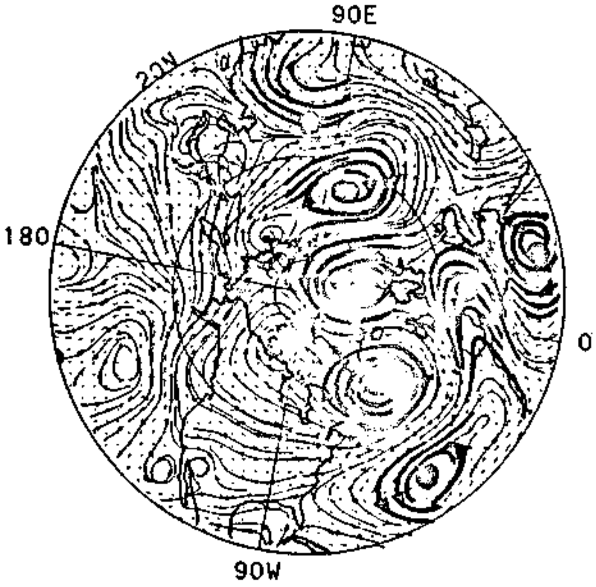

Fig. 1 - Mean configuration of circulation deviations at 200mb for the months of Dec/69, Nov/71, Dez/75, Jan/79, Jan/80 preceding the occurrence of drought in Nordeste. The NAEA(0) pattern which appears in this figure is taken as reference. The full circles indicate the position of maximum and minimum relative vorticity deviations.

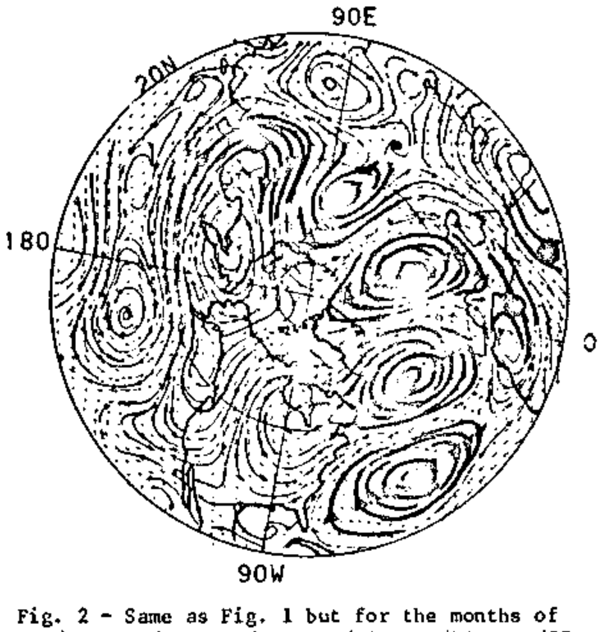

Fig. 2 - Same as Fig. 1 but for the months of Dec/63, Jan/71, Dec/72, Jan/74, Dec/76, Dec/77 preceding the occurrence of heavy precipitation in Nordeste, as indicated in Figure 3.

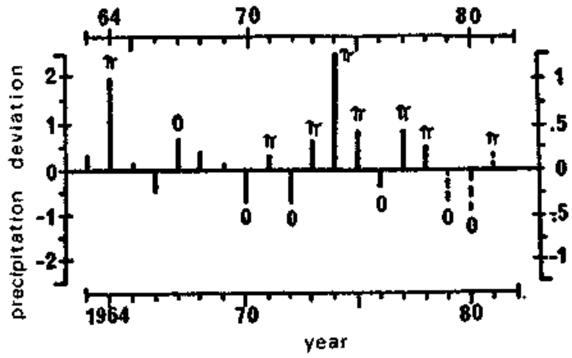

Fig. 3 - Yearly precipitation deviations of 32 stations in northern Nordeste normalized by standard deviation (continuous lines; from Hastenrath et al., 1984) and March, April, May mean precipitation for 20 stations normalized by the mean (broken lines; from De Brito, 1984). (0) and (π) indicate the phase of the NAEA observed pattern.

The present study indicates that, at least for the analysed period, the pattern NAEA(0) emerges prior to drought years in Nordeste, while the NAEA(π) pattern precedes very wet years. These patterns are sharpest mainly during December-January. Since the rainy season peaks in March-May there seems to be some predictive potential in these configurations, at least for extreme precipitation years. In December 1983 and January 1984, for example, the 200mb and 700mb geopotential height anomalies (figures not shown), as analysed by the Climate Analyses Center/NOAA (Climate Diagnostics Bulletin. Reports 84/1 and 84/2) clearly show a configuration like NAEA(π) pattern, indicative of a wet year. Nordeste was indeed very wet in 1984. Average rainfall departed about two standard deviations above the mean for the region as a whole.

It should be noted, however, that the month in which the wave-like pattern is sharpest do vary; in general it is the sharpest during December-January. Also for a few instances it was absent or had the "wrong" phase. For example, 1974 was a very wet year in Nordeste (Figure 3), but in December 1973 the observed NAEA pattern had phase 0 which would indicate a dry year. There was then a sudden phase reversal to π in January and February, 1974 indicating a wet year. For the sake of developing a forecast scheme there was, fortunately, no instance in which a sudden phase reversal would render a forecast wrong, say, a year in which the pattern would change from 0 (indicative of dry year) to π (indicative of wet year) in the months preceding the rainy season in Nordeste and then a drought occurred.

4. CONCLUDING REMARKS

In this work it has been shown that phase changes of a large-scale teleconnection pattern linking the North Atlantic to East Asia (NAEA pattern) might possibly be used in climatic prediction of extreme precipitation anomalies in Northeast Brazil.

However, the generating mechanism for such patterns and its relation to precipitation anomalies over Nordeste are not known as yet. It is very likely that the interaction between the tropical oceans and the atmosphere plays a vital role in determining the existence of both the circulation and precipitation anomalies. Stationary solutions of the linearized primitive equations on an sphere and forced by tropical heat sources (Hoskins and Karoly, 1981; and others) qualitatively resemble the wave-like pattern NAEA, but the link between these teleconnection patterns and deep tropical heat sources has not yet been clearly established. Nevertheless, this study gives support to the idea that extreme Nordeste rainfall anomalies are regional manifestations of planetary-scale phenomena.

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