humidity caused a decrease in the isotopic fractionation and in the leaf water ^{18}O content, and consequently, also in the organic matter ^{18}O content. Thus, information related to the past air humidity can be obtained from variations of ^{18}O organic contents.

For the Amazon trees, our analysis are suggesting the existence of three periods of higher air humidity since 1700 (Fig. 1). For example, the air relative humidity would have been, in 1700, 10% higher than today (Moreira, 1980).

Therefore, with a better knowledge of the steps that can cause fractionation during isotope absorption, it will be possible to know the past climatic conditions, when no human influence occurred.

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INFLUENCE OF SOUTHERN OSCILLATION (EL NIÑO) ON ATMOSPHERIC CIRCULATION AND PRECIPITATION OVER BRAZIL

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Introduction

Persistent anomalies of the general circulation of the atmosphere may result in drought in one region and excessive rainfall in another. A better understanding of the physical mechanisms governing these anomalies offer conditions for meteorologists to know in advance the regions that will be affected by drought or will have excessive rainfall.

The most well known climatic anomaly is the negative (or warm) Phase of southern oscillation or EL NIÑO phenomenon. In this paper, we will describe the EL NIÑO - southern oscillation (ENSO).

Southern oscillation

Early in the century, the presence of a pressure seesaw pattern between Buenos Aires, Argentina, and Sydney, Australia, was observed. When the pressure rises in Buenos Aires it drops in Sydney and vice-versa (Rasmusson and Carpenter, 1982). Walker (1924 and 1928) and Walker and Bliss (1932) studied this phenomenon and named it the Southern Oscillation (SO). Walker and Bliss (1932) noted that the pressure was high over the South Pacific and tended to be low over the eastern Indian Ocean and in the Indonesia region, with greater than normal precipitation in this area. Pressure time series of stations in Tahiti, South Pacific and Darwin, and Australia show a high negative correlation between these stations (Figure 1).

The intensity and phase of this oscillation is measured by an index. This index is computed by taking the difference of the pressure or its deviation from the mean between the two stations which represent the two centers of the SO action, normally being the Tahiti and Darwin stations. The positive value of the southern oscillation index (SOI) that corresponds to the positive, or cold phase, is computed when both the Indonesia low pressure system and the eastern Pacific subtropical high are stronger than normal. When these systems are weaker than normal the value of SOI is negative and the phase is negative or warm.

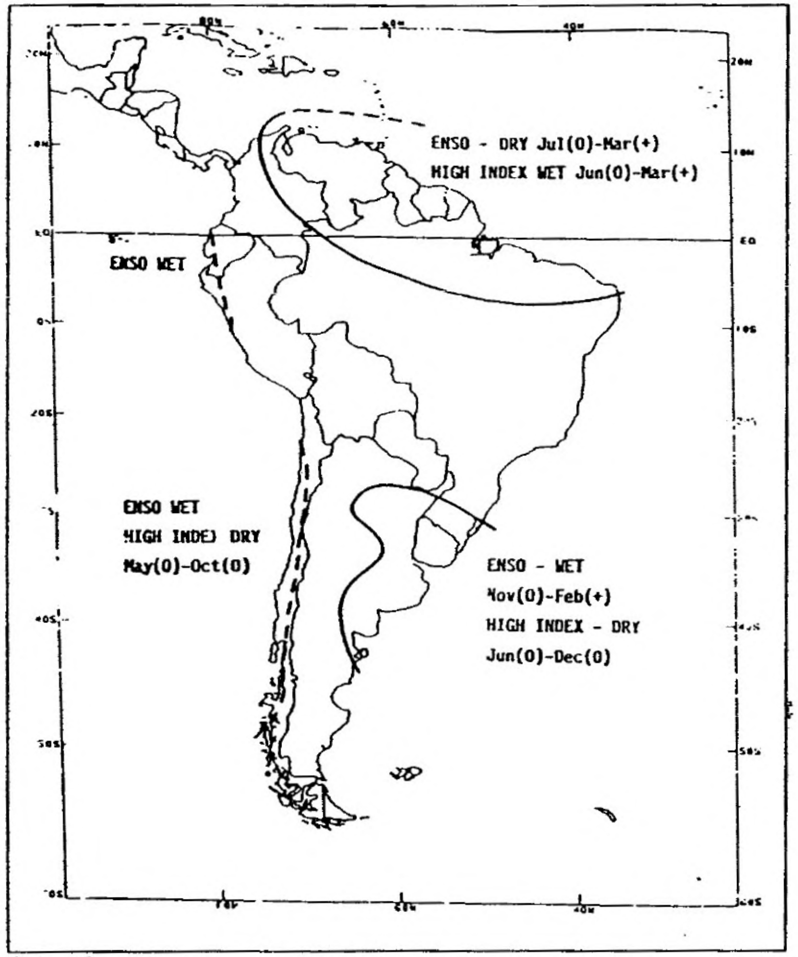

Figure 1

During the cold phase of SO the strong horizontal pressure gradient between Indonesia and Central Pacific permits the intensification of the easterlies and wind convergence in lower levels. This induces a high index of precipitation over

Indonesia. During this phase, western ocean currents and the equatorial upwelling are stronger than normal and the waters are colder than the mean over central Pacific. Besides, during the warm phase there is a decrease of the horizontal pressure gradient between the two centers of action. Henceforth, in the Indonesia region the trades, the wind convergence in low levels and the convective activity weakens and consequently the conditions are favorable for the occurrence of warmer waters than normal in the eastern Pacific.

Troup (1965) suggested that the variation of the southeast trades and the sea surface temperature (SST) have important effects in direct circulation between western and eastern hemispheres. Bjerkenes (1969) named it the Walker circulation.

El Niño phenomenon

El Niño is the event of warming of the surface waters of the tropical eastern Pacific Ocean during the summer time of the Southern Hemisphere. The appearance of warm waters is related with the weakening of the equatorial easterly winds in the Pacific.

In some years, when the SO is in negative phase an excessive warming in the tropical eastern Pacific surface waters is observed and the positive anomalies of the SST remain for several months. At present, the name El Niño is given to a warming anomalous of the tropical eastern Pacific Ocean (Rasmusson and Hall, 1983).

The formation of the El Niño event is connected with the weakening of the southeast trade winds that cause a slow flux of the Peru current. As the rate of surface heating does not decrease surface waters become warmer. Further the warming of the wind reduces the coastal and equator upwelling and as such diminishes the transport of cold water. Cane (1983) and Kousky and Ropelewski (1989) thoroughly describe the previous history of the El Niño phenomenon, some main characteristics are presented henceforth.

Build-up phase

During the period preceding the warm episode, trades stronger than normal are observed over the western equatorial Pacific for several months. This event moves the Pacific waters from east to west, and consequently the sea level becomes higher than normal in the western sector. At the same time, the thermocline in the western side becomes deeper than it's mean position. The SST is a few degrees warmer than normal far to the west and a few degrees colder to the east of 160E. Enhanced convection is observed over the region with warmer waters, while the convection is suppressed over the relatively cold waters. This implies the existence of a direct thermal and east-west circulation cell (walker's circulation).

Onset phase

During the build up phase, there is an increase and an expansion in the reservoir of warm waters and in convection in the western Pacific. In this phase the low level trades over the western equatorial Pacific weakens. Once the warm waters shift to east and cross the date line during the period from July to November, strong and persistent convective activities occur in the central and eastern Pacific region, marking the beginning of the mature ENSO phase.

Mature phase

This phase occurs during the Southern Hemisphere summer due to the fact that the equatorial SSTs in the central and eastern Pacific are near their maximum values. The extensive area of SST above normal in the equatorial Pacific contributes to an increase in the tropospheric heating in the tropical Pacific. Henceforth, the east-west thermal contrast diminishes and the Walker circulation weakens but the north - south thermal gradient raises and the Hadley circulation (circulation with ascendent movement in the tropical region and subsidence over the subtropical sector) is intensified. During the mature phase the subtropical jet stream becomes stronger then normal over the Pacific.

A readjustment occurs in the upper ocean structure. The oceanic thermocline that was shallow in the east and deep in the west during the build up phase changes to become deeper than normal in the east and shallower than normal in the west.

In this phase as well as on the onset phase warmer waters than normal appear along the equatorial west coast of South America. This is called the El Niño phenomenon.

Decay phase

During this phase there is a rapid return to normal conditions. It begins when the equatorial trades over the central Pacific are near their peak in their seasonal cycle (January) and there is a rapid decrease in the extent and magnitude of positive SST anomalies in the equatorial Pacific.

Effect of ENSO on the precipitation over South America

The ENSO event of 1982-83 was well largely studied because it was intense. Kousky *et al* (1984) studied the effect of El Niño on the precipitation over Brazil and concluded that there was drought in the Northeast and Amazon region and intense rainfall over the southern region.

The table 1 shows the normal mean annual precipitation compared to the precipitation of 1983 for the same station of southern and southeastern region of Brazil. It is evident that the precipitation during July was larger than the normal mean of April - July. Through satellite images Kousky and Cavalcanti (1984) observed that the abnormal precipitation over south Brasil in 1983 was associated to frontal systems that penetrated into this region for a longer period of time with a great convective activity. During fall and winter this system extended from south of the continent and moved fast towards north and east reaching the subtropical jet latitude.

Recent studies of Ropelewski and Halpert (1987, 1989) have shown the relation of the two phases of SO and the precipitation over many regions of the globe. For South America they identified three regimes of precipitation (Fig. 2):

- western coast region;
- northeastern sector, including Venezuela, Guyana, Surinam, French Guiana and the near equatorial regions of Brazil;

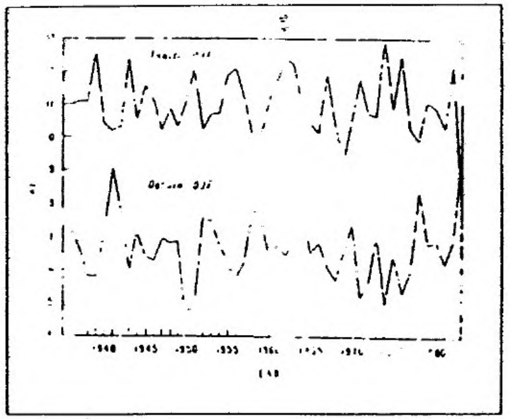

Figure 2

- southeastern sector formed by southern Brazil, Uruguay and parts of northern Argentina.

In El Niño years the following precipitation regimes were observed in these regions (Ropelewski and Halpert, 1987 and 1989):

- In the normal arid western coast region heavy rains occurred;
- In the northeastern region, of the 18 El Niño events 17 were associated with dry conditions during the period from July (onset phase) through March. Of the 11 driest months in march, nine were associated with El Niño events.
- For the southeastern sector 15 of the 17 El Niño events, were associated with rain above normal during the period from November through February. Of the 10 wettest periods from Nov-Feb, 7 were associated with El Niño.

During the positive or cold phase of SO the precipitation anomalies tend to behave opposite to the warm phase (Table 2). Furthermore, of the 17 cold episodes, 13 were associated with precipitation above normal during the period from June through March in northeast of South America. In the southeastern region they observed that of the 20 cold episodes, 17 were dry and 2 of the 3 driest years were associated with cold phase of SO.

Table 1 Normal mean rainfall and precipitation in 1983 for the same station of southern and southeastern regions of Brazil. Adapted from Kousky and Cavalcanti (1984). JFM = sum of January, February, & March AMJJ = sum of April, May, June, & July

	São Paulo (SP)		Curitiba (PR)		Campos Novos (SC)		Florianópolis (SC)		Porto Alegre (RS)	
	Normal	1983	Normal	1983	Normal	1983	Normal	1983	Normal	1983
Janeiro	254	239	198	268	147	113	171	280	120	88
Fevereiro	227	278	175	77	130	304	164	237	104	159
Março	172	179	125	108	135	158	141	152	89	166
Abril	81	101	78	149	156	100	133	178	102	90
Maio	54	191	85	331	125	382	107	205	114	172
Junho	55	221	89	227	135	167	78	177	139	100
Julho	43	42	82	265	134	316	74	514	128	219
JFM	653	696	498	453	412	575	476	669	313	413
AMJJ	233	555	334	972	550	1445	392	1074	483	591

Table 2 Historical summary of the Southern Oscillation related precipitation anomalies. The "0" represents the episode year and "+" the year following. From Kousky and Ropelewski (1989).

NORTHEASTERN REGION

SEASON	WARM EPISODES			SEASON	COLD EPISODES		
	TOTAL	WET	DRY		TOTAL	WET	DRY
JUL(0)-MAR(+)	18	1	17	JUN(0)-MAR(+)	17	13	4

SOUTHEASTERN REGION

SEASON	WARM EPISODES			SEASON	COLD EPISODES		
	TOTAL	WET	DRY		TOTAL	WET	DRY
NOV(0)-FEV(+)	17	15	2	JUN(0)-DEC(+)	20	3	17

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RECORDS OF BLOCKAGE OF POLAR ADVECTIONS AND ATMOSPHERIC CIRCULATION OVER SOUTH AMERICA, DURING THE LAST 5,000 YEARS

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The atmospheric circulation over South America

The normal condition of air mass circulation over South America during the austral autumn and winter is characterized by the passage, within the middle and upper troposphere, of a succession of meridian waves and, on the surface, by corresponding frontal systems. On the sea surface, the frontal systems are accompanied by winds and waves which come from the Southern sector. Its effects are felt as far as latitude 12° S (Fig. 1). In periods of strong El Niño activity, the polar advections are blocked by a powerful and permanent jet current which extends from the Peruvian coast toward Southern Brazil (Fig. 1b). Due to this blockage, the frontal zones and the associated southern sector waves do not ascend northwards. Consequently, derangements of some natural mechanisms.

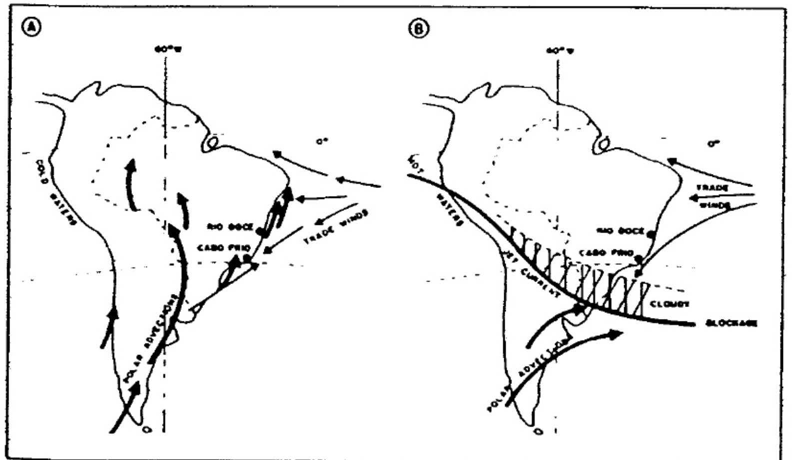

Figure 1 Schematic atmospheric circulation over Atlantic South America (A) Normal Conditions (B) El Niño (1983) conditions