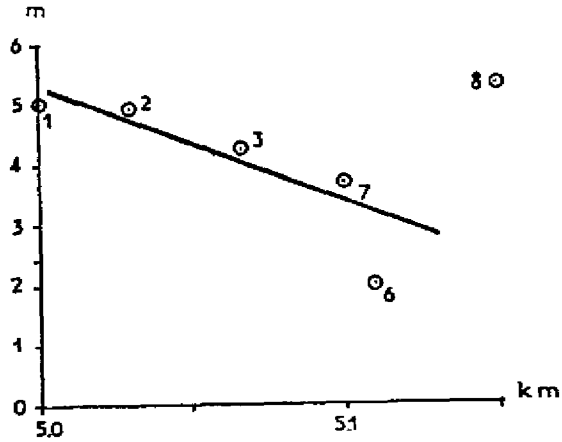

Fig. 2 B : Evolución del balance en función de la altura. La linea de equilibrio del glaciar se habría ubicado a 5 250 m s.n.m., sea más arriba que la cumbre.

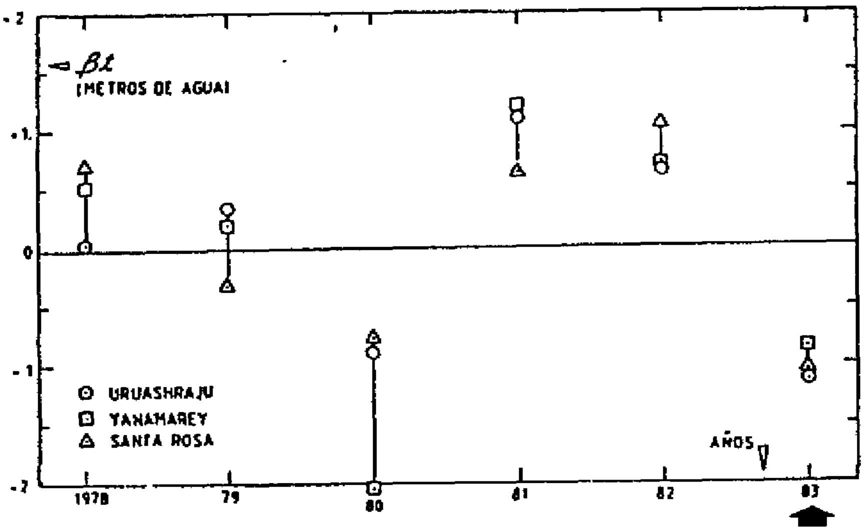

Fig. 3 : Variación del balance en función del tiempo sobre 3 glaciares de la Cordil[lera] Blanca (según Ames, 1985).

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PRECIPITATION PATTERNS IN MEXICO ASSOCIATED WITH THE EL NIÑO/SOUTHERN OSCILLATION (ENSO)

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Regímenes de precipitación en México asociados con eventos niño/oscilación suriana

Resumen- Utilizando espectros cruzados y análisis armónico se determinan los regímenes de precipitación asociados con un ENSO compuesto (1950-1980) observado en la SST y en el NMM (SLH), en las costas del Pacífico Mexicano. Al graficar los vectores en un mapa de México se encuentran al menos cinco regímenes de respuesta coherente. Cada régimen presenta parámetros estructurales ∝ y ß de la distribución gamma característicos de la precipitación durante eventos ENSO y de La Niña. De manera general se puede establecer que durante el año (O) de un evento ENSO se presenta el máximo de precipitación en Julio mientras que en el año (+1) el máximo se desplaza a septiembre.

Using long-term precipitation records from 187 stations it is studied the precipitation regime associated with a composite ENSO (1950-1980) observed on the SST and SLH along the Mexican Pacific coasts. Monthly composites of precipitation characterizing ENSO events are analyzed with cross-spectrum and harmonic analysis and plotted as a harmonic dial vector. When plotted on a map of Mexico these vectors reveal booth the regions of coherent response and the phase of the responses with respect to the evolution of the ENSO episode. The analysis shows that there are at least five general different precipitation patterns: Each regime shows characteristic structural parameters ∝ and ß of the gamma distribution during ENSO and La Niña episodes. The results show that ENSO effects are masked by the mid-summer drought in the eastern half of the country; while it shows a remarkable effect in both the Pacific plains and northeastern Mexico. It is found that in general during year (1) of an ENSO event the maximum precipitation occurs in July while in the year (+1) the maximum is shifted to September.

1. Introduction

In recent years new insigths have being provided on the evolution of the El Niño/ Southern Oscillation (ENSO) and corresponding anomalies in surface temperature and precipitation over the equatorial Pacific (e.g. Rasmusson and Carpenter, 1982). The above authors and also Shukla and Paolino (1983) confirmed that the summer monsoon precipitation over India is supressed during ENSO. Earlier, Hastenrath (1976) found a significant correlation between the rainy season and sea temperature off Peru and Ecuador. Recently, the geographical extent, magnitude, phase and duration of ENSO-related precipitation on global and regional scales has been described by Ropelewski and Halpert (1986). An association between the modes (High/Dry and Low/Wet or warm event) of the southern oscillation and precipitation variability has been found for the Caribbean and Tropical Americas (Rogers, 1988).

The purpose of this paper is to focus on precipitation patterns of Mexico associated with a composite of sea surface temperatures and sea level heights for seven ENSO events occurred between 1950 and 1980 along the Mexican Pacific coasts.

2. Data

The analysis is based on 187 surface metereological stations from which monthly precipitation totals for periods between 1900-1980 are used. Also monthly sea surface temperatures (SST) and monthly sea level heights in Mexico for period 1950-1980 are utilized. The sources of these data are the Servicio Metereologico Nacional and the Instituto de Geofisica, UNAM (responsible of the tide gages network). No attempts were made to correct for apparent biases or errors in the station data, but individual stations whose time series exhibited discontinuities or missing data were eliminated from the analysis. Thus the precipitation data set spans for eighteen ENSO events occurred between 1900 and 1980. The ENSO years used as the basis for the composite analysis are those defined by Rasmusson and Carpenter (1983).

3. Methods

The amplitudes of different El Niño episodes can vary significantly, however the phases of the different episodes can be remarkably similar (e.g. Rasmusson and Carpenter, 1983). This behavior of ENSO makes possible the use of composite analysis (Philander, 1989).

a. Sea level heights and sea surface temperatures

Monthly means of sea level and sea surface temperature data from the hydrographic stations of Salina Cruz (16.2c°N, 95.2°W), Acapulco (16.8°N, 104.3°W), Manzanillo (19[illegible] 104.2°W), Mazatlan (23.1°N, 106.4°W) and Ensenada (31.8°N, 116.6°W) were used to obtain anomalies.

Sea level anomalies (SLA) have been determined in accordance with Wyrtki (198[illegible]) by the relation:

$$SLA = SLH - MSL - MAC \qquad (1)$$

where:

SLH denotes individual values of monthly mean sea level heights.
MSL denotes mean sea level during the La Niña years.
MAC denotes the mean annual cycle. MAC has been determined by the non-inte[illegible] technique of power spectrum analysis. The estimated values of MAC are very near to those documented by Wyrtki and Leslie (1980).

Sea surface temperature anomalies SSTA have been estimated using the sim[illegible] relation

$$SSTA = SST - LSST \qquad (2)$$

where SST denotes the monthly sea surface temperature and LSST is the long term monthly average of sea surface temperature for each station during the La Niña years.

The anomalies given in (1) and (2) are considered statistically significant at 95% confidence level if $\geq | 2 \infty |$.

The time series of anomalies both SLA and SSTA for ENSO events were used to form the ENSO composites as Rasmusson and Carpenter (1982) documented for sea surface temperatures at the South American coasts.

b. Precipitation

Rainfall data are adjusted to a gamma distribution. The analysis of precipitation is analogous to that used by Ropelewski and Halpert (1986). The composite percentile ranks were fitted by a 24-month harmonic. The (-1,0,+1) refers to months in the year previous, during and following an ENSO event according with Rasmusson and Carpenter (1983) convention.

4. Results

Fig. 1 shows the composite of SST anomalies for the seven most significant warm episodes between 1950 and 1980 along the Mexican Pacific coasts between 16°N and 31°N. It is found that the year (-1) begins relatively cold to become near normal, it has a maximum anomaly during June of about 0.5°C. The year (0) shows a first peak of temperature anomaly in May, August becomes normal to start increasing SST anomaly in September reaching the second maximum in December and January of the year (+1). Maximum composite anomalies are near to 1.5°C.

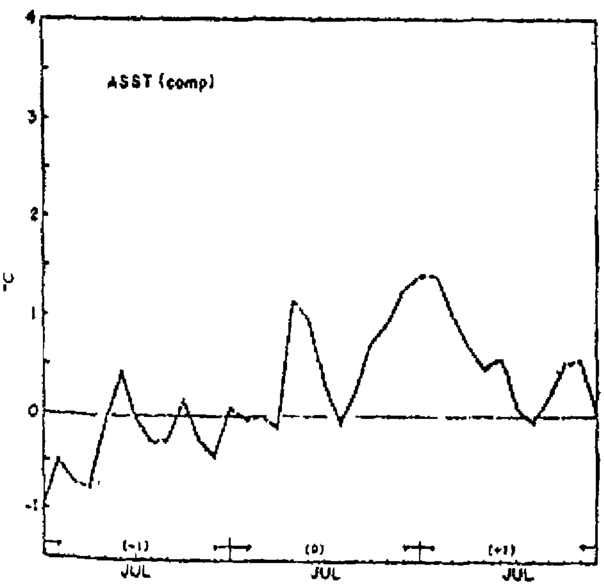

FIG. 1 ANOMALIES OF SEA SURFACE TEMPERATURE COMPOSITE FOR SEVEN ENSO EVENTS (1950-1980) AS OBSERVED FROM SALINA CRUZ (16.1° N, 95.12° W) TO - - ENSENADA (31.8° N, 116.6° W)

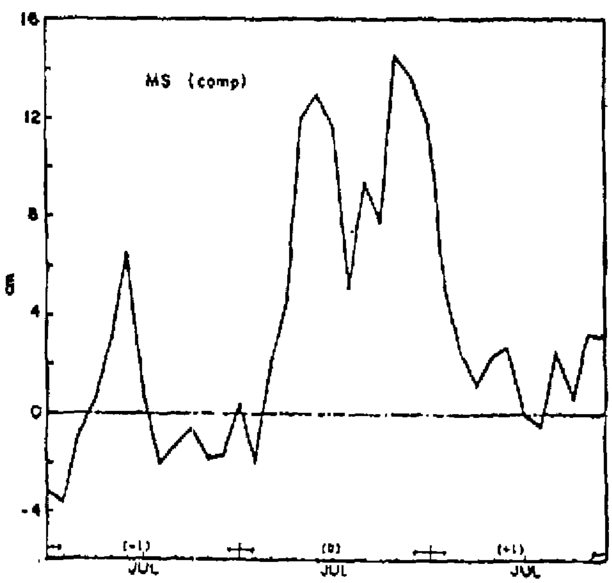

FIG. 2 ANOMALIES OF SEA LEVEL HEIGHTS COMPOSITE FOR SEVEN ENSO EVENTS AS OBSERVED FROM SALINA CRUZ (16.1° N, 95.12° W) TO ENSENADA (31.8° N, 116.6° W)

Fig. 2 Shows a composite of sea level heights for the same period of time and geographical extent as it is given in Fig. 1. It is found that there is a remarkable coincidence of the temporal distribution both of SST and SLA. Of course this behavior it is also observed on the annual variation of SST and SLH under "normal" conditions.

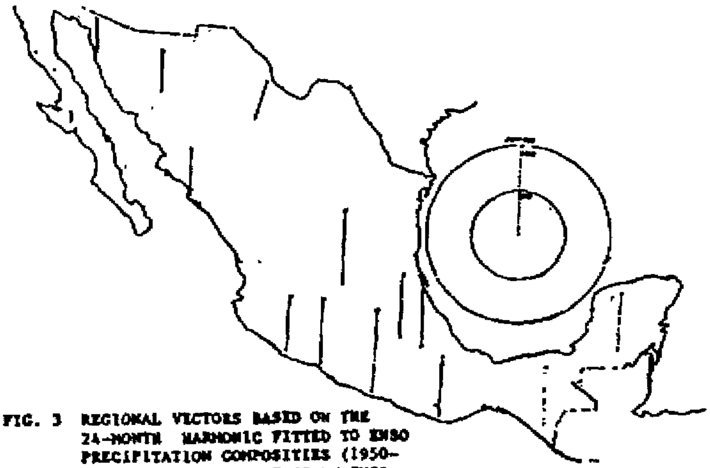

FIG. 3 REGIONAL VECTORS BASED ON THE 24-MONTH HARMONIC FITTED TO ENSO PRECIPITATION COMPOSITIES (1950-1980). A MINIMUM OF SEVEN ENSO EVENTS IS REPRESENTED BY EACH VECTOR.

The map of Fig. 3 shows some of the station vectors based on the 24-month harmonic fitted to ENSO precipitation composites. A minimum of seven ENSO events is represented by each vector. Two large regions can be identified. The first region it covers about two thirds of the country extending from the central to the southern part. This large area shows the largest vector magnitudes.

The largest magnitudes is obtained along the Pacific coasts from the States of Oaxaca, Guerrero, Jalisco, Michoacan, Colima, Sinaloa and Nayarit.

The second coherence region of precipitation extends from the northern part of the country up to the northwestern including part of the Baja California peninsule. The vectors in this region are smaller.

Fig. 4 shows mean monthly precipitation for ENSO and La Niña events at one station located in the region of maximum vector amplitudes. It is seen that July attains the maximum value (ca. 30%) during the year (0) of ENSO.

Fig. 5 is the same as Fig. 4 but for year (+1) of ENSO. Here the maximum precipitation (ca. 20%) over the mean occurs in September.

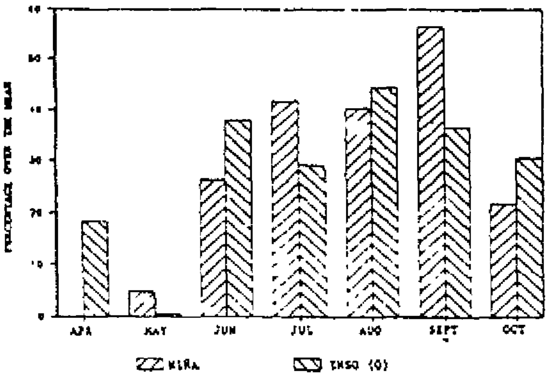

FIG 4 MANZANILLO (19° N, 104.2° W) MONTHLY PRECIPITATION OVER THE MEAN DURING THE ENSO YEAR (0)

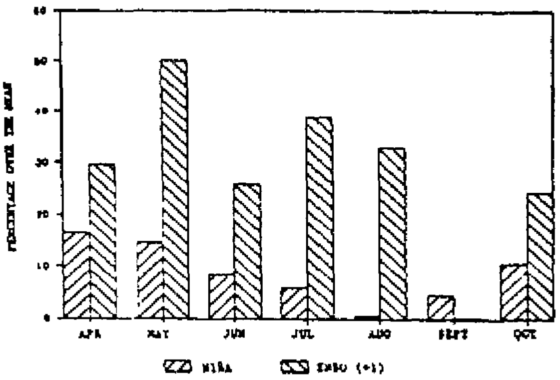

FIG. 5 MANZANILLO (19° N, 104.2° W) MONTHLY PRECIPITATION OVER THE MEAN DURING THE ENSO YEAR (+1)

Conclusions

1. ENSO composites of sea temperature and sea level along the Mexican Pacific coasts show a first maximum during may of year (0) and a wide response of high anomalies from September (0) to March (+1), maximum values are reached in December (0) and January (+1).
2. The analysis shows that there are at least five precipitation patterns associated with ENSO events. Four of them show precipitation above normal during ENSO episodes. The highest vector amplitudes are observed along the Central part and South Pacific coasts. Minimum vector amplitudes are found on the northwestern.
3. Regions of high coherence show characteristic α and β structural parameters of the gamma distribution during ENSO and La Niña events.

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VARIACIONES ESTACIONALES DE TTEMPERATURA, SALINIDAD Y OXIGENO DISUELTO EN LA SUPERFICIE DEL MAR FRENTE A LAS COSTAS DEL PERU Y EL FENOMENO ENSO 1972-73, 1982-83 Y 1987

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El presente trabajo describe las características térmicas, halinas y de contenido de oxígeno disuelto en la superficie del mar para una escala temporal de 31 años (1960-1990) para el área comprendida entre las costas del Perú y las 200 m.n., y entre los 03° 30' y 18° 20'S., empleándose toda la información disponible del Banco de Datos Oceanográficos del IMARPE. Además, se analizan las anomalías de las variables físicas superficiales (temperatura y salinidad) y químicas (oxígeno disuelto) asociadas a la ocurrencia de los eventos ENSO 1972-73, 1982-83 y 1987; comparándolas con la distribución media estacional y mensual de estos parámetros. Para tal fin se estudia el comportamiento de la temperatura superficial del mar en las estaciones costeras fijas del IMARPE (Tumbes, Paita, Chimbote, Callao, Pisco e Ilo) y la DHNM (Chicama), así como las condiciones oceánicas locales de la superficie del mar frente al Perú relacionándolas con aspectos globales del Fenómeno ENSO. Finalmente, se efectúa un análisis estadístico a fin de evaluar la intensidad de las fluctuaciones ambientales frente a las costas peruanas en los años 1972-73, 1982-83 y 1987.

Los resultados indican gran variabilidad estacional en los regímenes físicos en las zonas norte y sur mar afuera, y la influencia de aspectos locales en la dinámica del afloramiento frente a la costa.