ENSO Signals on Sea-surface Salinity in the Eastern Tropical Pacific Ocean

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INTRODUCTION

Beyond the various oceanographic parameters measured in the eastern tropical Pacific, sea surface salinity (SSS) data are analyzed to assess the regional impacts of El Nino-Southern Oscillation (ENSO) events.

Focus is made on the large contrast (Fig 1) in sea surface salinity between to area:

a) at the extreme eastern part of the Inter Tropical convergence zone of the wind (ITCZ), the Panama Gulf north of the equator there is a net freshwater input for the ocean from atmosphere. In addition to low salinity waters due to an excess of precipitation over evaporation the North Equatorial Counter Current (NECC) carries eastward low salinity waters. The salinity is lower than 33.O psu (practical salinity unit).

b) south of the equator, evaporation largely dominates resulting in high sea surface salinity carried westward by the South Equatorial Current (SEC) which constitute the northern branch of the large anticyclonic subtropical gyre. The salinity is larger than 36.0 psu near Tahiti.

Between these two water masses of salinity characteristics largely differents, the equatorial upwelling usually prevail. The signature of upwelling is well seen on SST which decreases significantly at the equator mainly during the august to november period. The waters from below, colder and saltier, are raised to the surface and spred north and south of it. The largest salinity contrast at sea surface is well seen north of the equator between the salty upwelled waters and the low salinity waters of the Gulf of Panama but need to be detected with improved techniques of measurement.

BASIC MONITORING

The monitoring of the SSS in addition to the SST monitoring is of primary importance because sea-surface salinity reflects the hydroclimatic conditions of the region. It is a prominent parameter in oceanic studies and its distribution may condition and/or reflect mass and heat exchanges between the ocean and the atmosphere. The global circulation models need accurate data of salinity distribution in region of large spatial and temporal contrasts in oceanic parameters.. Unfortunately while large improvements were made in the temperature monitoring (XBT, IR satellite imagery, instrumented moorings), salinity remains poorly monitored over the oceans.

However, SURTROPAC Group based at ORSTOM center (Noumea / New-Caledonia) started routinely observations from commercial vessels in the western Pacific in 1969. The network growth and covered a large part of the tropical Pacific crossing equator at several longitudes since 1974, the eastern line between Panama (Central America) and Papeete (French Polynesia). Despite of large difficulties to sample sea water with meteorological bucket (every 6 hours) and to measure salinity of the samples at the lab in ORSTOM center at Noumea few months later, this effort represents the most significant SSS data set for oceanographic large scale studies in the Pacific ocean.

SEASONAL AND INTERANNUAL SSS VARIABILITY IN THE EASTERN PACIFIC

Despite of the low time-space coverage a gridded SSS product (10° longitude, 2° latitude, 1 month) allowed to perform a SSS mean distribution (Fig 1) and SSS deviation (Fig 2) to estimate its variability which is maximum in the region of Panama Gulf. In the eastern Pacific studies from Donguy and Henin (1980) and Delcroix and Henin (1991) emphasized the seasonal and the interannual variability along the track Panama to Tahiti. They described for the first time the impact of ENSO on the distribution of sea surface salinity

Seasonal variability

Figure 3 shows the mean annual and the seasonal salinity cycle along the track relative to the latitude. (left) : seasonal cycle of SSS along the eastern track (right) : mean year for SSS is calculated for each track using the monthly gridded values but omitting the ENSO years The standard deviation over the 12 months which measure the seasonal variability reaches 0.38 near Panama. North of the equator there is a strong SSS signal with a mimimum occurring in February-March, concomitant with the peak of near equatorial rainfall associated with the southernmost annual position of ITCZ (Hastenrath and Lamb, 1977). The contribution of salt advection is not easy to estimate. However we note that the minimum SSS coincide with the February to May reversal period of the South Equatorial Current (SEC) which reduces the usual import of high salinity water from the region of Peru (Halpern, 1987)). South of the equator no particular SSS signal is detected except near Tahiti.

Interannual variability

The Empirical Orthogonal Function method (EOF) has been used to bring out SSS variations on the Tahiti to Panama line. The first EOF function account mostly for the seasonal variability while the second EOF function (Fig 4) account for 21% of the total variance and mainly depicts the interannual variability. The time function is not correlated with the Southern Oscillation Index (SOI) although it separates the 1976-1977 and 1982-1983 ENSO events from the remaining time series. The associated space function indicates maximum SSS decreases at the equator and within 8-12°S while maximum SSS increase is observed near Tahiti at 18°S. This increase of SSS in the central south Pacific is the consequence of the equatorward shift of the South Pacific Zone Convergence Zone (SPCZ) which concerns the western and central south Pacific ocean. Opposite SSS interannual variability is thus observed on this shipping line between the eastern equatorial Pacific and the central south Pacific.. The lack of ENSO-related SSS signal in 1986-1987 suggests that a moderate El Nino event is not sufficient to affect the SSS field along the eastern track.

THERMOSALINOGRAPH NETWORK

Due to the difficulty of sea water sampling from meteorologial bucket, ORSTOM developped a Thermosalinograph (TSG) network on commercial vessels which measure accurately the sea surface temperature and salinity at a high rate of sampling along the shipping route. A median value over 20 measurements is recorded every 5 minutes. The accuracy is considerably improved (0.02 psu for the TSG technique instead of 0.2 psu with bucket technique).

First results concern the western Pacific with the description of the zonal displacements of sharp salinity front at the eastern end of the « Warm Pool ». It has been proposed to name « Fresh Pool » the low salinity area which float over saltier waters and is separated from adjacent saltier waters by sharp salinity fronts (Fig 5) (Hénin et al, 1997). Only TSG systems may detect such fine surface structures.

The TSG network is in developpement on a «Tour du Monde» shipping line which crosses the three tropical oceans (France-Panama-Tahiti-Noumea-Australia-Indonesia-Red Sea-Mediterranean Sea). On the Panama to Tahiti transect the thermosalinographs recorded very sharp fronts between the Panama Gulf and the South Pacific tropical waters. Main front has been observed near 2°N. Other fronts are observed near 10-12°S. Figure 6 presents the temperature and salinity records obtained on the CGM RIMBAUD, the PROVIDENCE and CGM RONSARD during experimental voyages. A large change is seen on the temperature record due to the absence of upwelling in october 1997 during the present El Nino event.

Two ships only are actually monitoring the Panama to Tahiti line, a complete voyage around the world lasting 3 months. It is hoped that this line will be sampled regularly with approximately 6 to 8 voyages per year, providing interesting data on SSS variability in the eastern Pacific. However the southern hemisphere portion is far away from the coastlines of South America. The SSS variability of the eastern south hemisphere is therefore very poorly known until a meridional line (between California and Peru for instance) is selected to do TSG measurements.

We actually prepare the real-time transmission of SSS data from TSG allowing a better monitoring of the SSS variability, component of the international Ship of Opportunity Program (SOOP) in the framework of CLIVAR (Climate Variability and Prediction Program)

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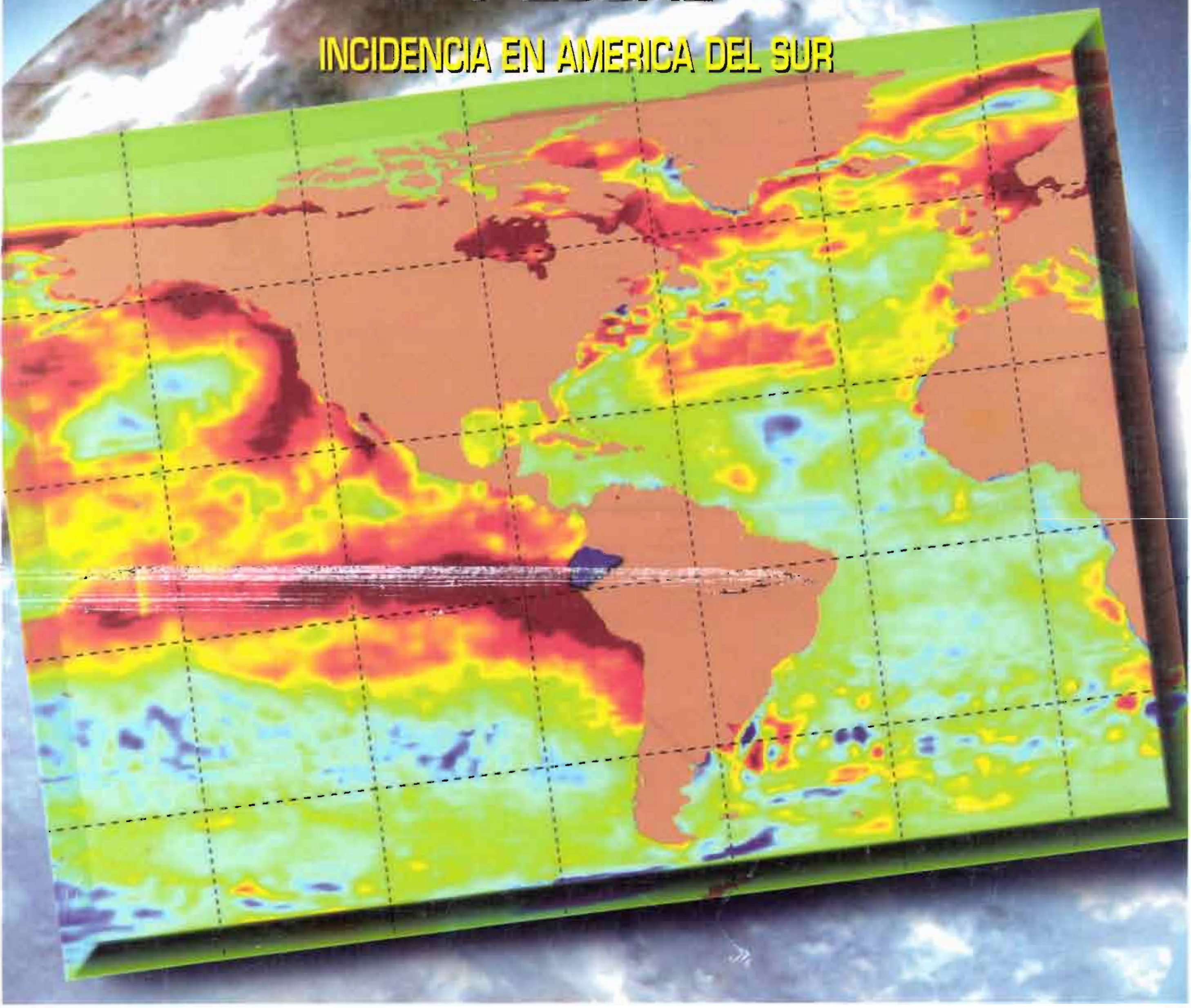

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