Response of Air Surface Temperatures over Central America to Oceanic Climate Variability Indices

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ABSTRACT

In this study were used 337 grid points (0.5 ° latitude x 0.5° longitude), over Central America, from a monthly air surface temperature data set. The annual cycle, secular trend and decadal variability were removed and seasonal series were calculated. Then multiple regression models were adjusted between the temperature first principal components (dependent variables) and several Sea Surface Temperature indices (independent variables) for all the seasons. These models show that indices related with El Niño-Southern Oscillation (ENSO) have the main influence over the region when compared with the influence of the other indices, having positive correlation with all the surface temperature seasons. It could be an indicative of latent and sensible heat transfer from the ocean to the overlying atmosphere. All these models had percentage of detection greater than 50% and false alarm rates lower than 10%. In the decadal scale, the temperature in Central America shows similar relationships with the tropical Atlantic and Pacific oceans through positive correlations with both oceanic regions.

1. Introduction

Portig (1976), classified the annual cycle of air surface temperature in Central America as tropical, predominantly maritime, with small annual changes and dependant on the cloud cover and altitude. Recently, several studies as Delgadillo *et al.* (1999), show that most of the climatic variations and resulting impacts on human populations in Central America derive from the non-seasonal variations that accompany interannual and interdecadal changes in the Tropical Atlantic and Pacific Oceans and their interactions with the overlying troposphere (Mestas-Núñez and Enfield, 2001).

Anomaly air surface temperature events, mainly those warmer than normal, could affect the water available for agriculture, energy, human consumption and recreation, but, the complex geography and the lack of good data sets, have made that relation difficult to quantify, yet clearly Central America has a strong climatic association, through teleconnection mechanisms, with the east equatorial Pacific (El Niño region, mainly) and tropical north Atlantic (TNA) (Enfield, 1996; Waylen *et al*., 1996).

The practical reasons mentioned above account for the lack of efforts on local climate prediction (Hastenrath, 1995), that have been focus in rainfall climate predictions as the study of Alfaro and Cid (1999). They showed that the TNA has the largest influence over the precipitation in the region when compared with the influence of the other indices. Having a different approach, Enfield and Alfaro (1999) and Alfaro *et al.* (1998), had shown that the influence of the surrounding oceans is not stationary around the year. In order to study anomalous behavior of the rainy season over Central America, tropical Atlantic and Pacific Ocean indices were used to produce correlation series with the starting and ending date of the rainy season. Those works showed that TNA and South Oscillation Index (SOI)-Niño3 indices, have

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the main correlations with the start and the end of the rainy season, respectively. Also, those studies allowed the creation of one prediction scheme that was later used with success in Costa Rica (Alfaro and Enfield, 1999).

Meanwhile, to explore the influence of the surrounding tropical oceans near the Central American Pacific coast, Alfaro and Lizano (2001) adjusted Transfer Function Models to Sea Surface Temperature Anomalies (SSTAs) of the Gulfs of Tehuantepec, Papagayo, Panama and the port of Quepos time series, using as independent variables Niño 3.4, tropical north and south Atlantic indices. These models showed that Niño 3.4 has the most important influence over the region when compared with the influence of the other indices, having positive correlation with all the regional SSTA series that could be related with the relative termocline's depth in front of the Central American Pacific Coast.

The main objective of this study is to construct seasonal prediction models for the air surface temperature anomalies (ASTAs) in Central America using, as predictor variables, previous seasons of several SSTAs indices associated to tropical climate variability. Also, a second objective is to investigate the correlation between the leading EOF modes of the ASTAs in the isthmus and some global SSTAs modes in the decadal scale.

2. Data sets and methods

Monthly data for the air surface temperature (AST) were compiled by the Centro de Ciencias de la Atmósfera in the UNAM, Mexico. They used data from gauge stations, satellite outputs and numerical models to produce the grids, which are 0.5° latitude x 0.5° longitude. The time period covers from January 1958 to August 1999. Only points over or very close to land in Central America covering 78.0-95.0°W, 7.5-21.5°N, were used in this study (Fig. 1). In

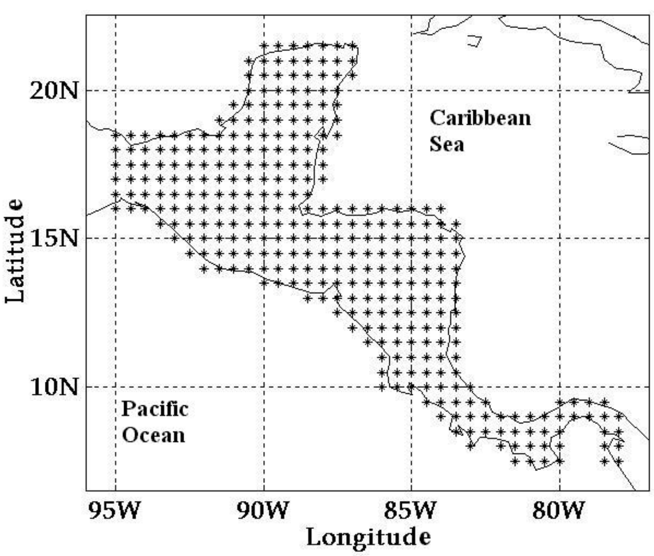

Fig. 1. Air surface temperature data points used.

order to validate the grid data, the record of thirteen available meteorological stations were correlated with the nearest grid data point and eleven of them were positive with a significance level greater than 95% and two of them, also positive, showed a significance level greater than 90%. This reduction in significance could be caused for the grid processes in which different climatic regimes are average together.

The oceanographic indices used include Niño zones: 1&2 (coast-90°W, 10°S-equator), 3 (90-150°W, 5°S-5°N), 3.4 (120-170°W, 5°S-5°N) and 4 (150°W-160°E, 5°S-5°N); the TNA (15-80°W, 6-22°N) and TSA (15°E-35°W 22-2°N) described by Enfield (1996) as indices that are related with climate variability of the Central American region.

Also, there were used SOI index (Tahiti-Darwin surface pressure difference) and indices of the Warm Pool near the Central American coast called tropical eastern north Pacific (ENP) and Intra-Americas Sea (IAS). This pool was taking as the size of the enclosed area of SST equal to 28.5 °C or greater (Wang and Enfield, 2001). This warm pool has proved to have an influence on the Central American precipitation, mainly on the Mid Summer Drought (Magaña *et al.*, 1999). In spite that some indices are associated to the same phenomena (ENSO events), all of them were included in order to detect a probable space-time lag that could be more useful for a specific prediction scheme. The lag zero correlation between all the indices used is presented in the Table 1.

Table 1. Lag zero correlation coefficient between the indices used, Jan. 1958-Aug. 1999. Those in italic are significant at the 95% level according to Ebisuzaki (1997).

	Niño 3	Niño 3.4	Niño 4	SOI	ENP	IAS	TNA	TSA
Niño 1&2	*0.8*	*0.68*	*0.53*	*-0.48*	*0.42*	*0.36*	0.07	-0.05
Niño 3		*0.96*	*0.81*	*-0.66*	*0.39*	*0.34*	0.11	0.05
Niño 3.4			*0.9*	*-0.7*	*0.34*	*0.3*	0.14	0.05
Niño 4				*-0.68*	*0.3*	*0.28*	*0.22*	0.04
SOI					*-0.22*	*-0.17*	-0.05	0.01
ENP						*0.85*	*0.4*	*0.27*
IAS							*0.4*	*0.24*
TNA								0.09

As a first step (Fig. 2), decadal variability and the trend were subtracted from the standardized anomaly by using a triangular moving average of 121 points for all the grid points and indices (Soley, 1994). Then, for all the ASTA series described before, were calculated four seasonal time series, as a three month average for boreal winter (December-January-February), spring (March-April-May), summer (June-July-August) and autumn (September-October-November). This seasonal division is to agree with the actual seasonal forecast made by the national meteorological services of the region and also this helps to focus forecasts in seasonal time scales.

After that, unrotated principal component analysis was used to reduce the dimensionality of these ASTA seasonal series. The number of components retained was obtained, in a subjective way, using the "*scree"* graph (Wilks, 1995), plotting the explained variance associated to each component (Fig. 3). The location of the "break" in the plotted curve was identified, most of the times, when the explained variance of two successive components, compared in descended order, was less than three percent.

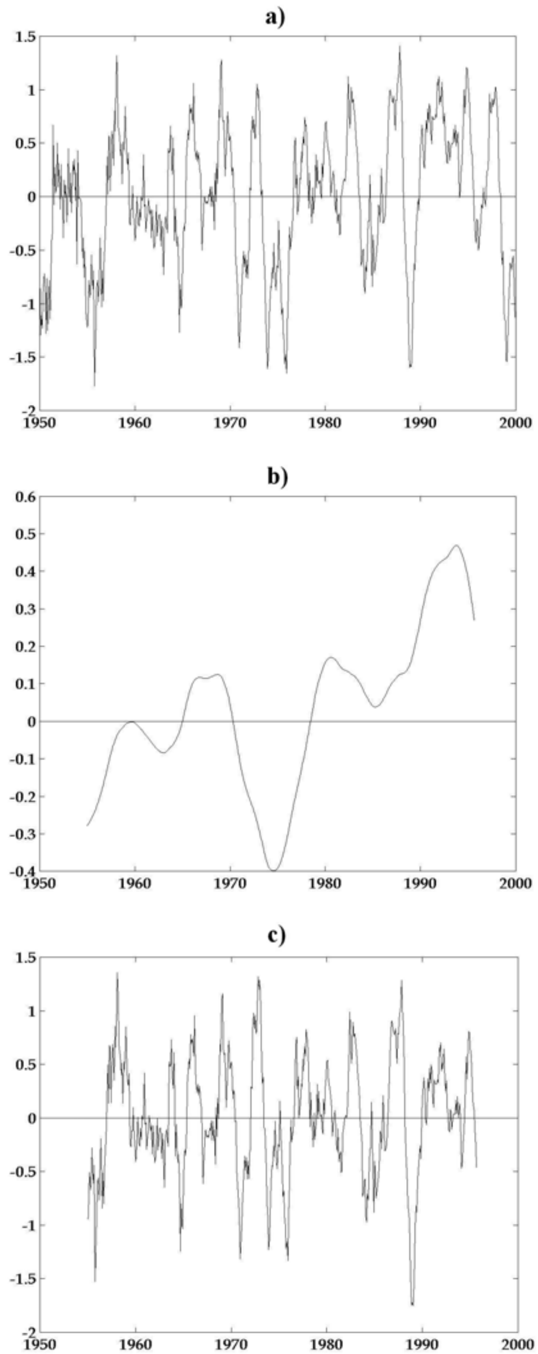

Fig. 2. a) Niño 4 series, b) trend and decadal variability associated to this series and c) Niño 4 series with its trend and decadal variability removed. Notice that vertical scale axes are different.

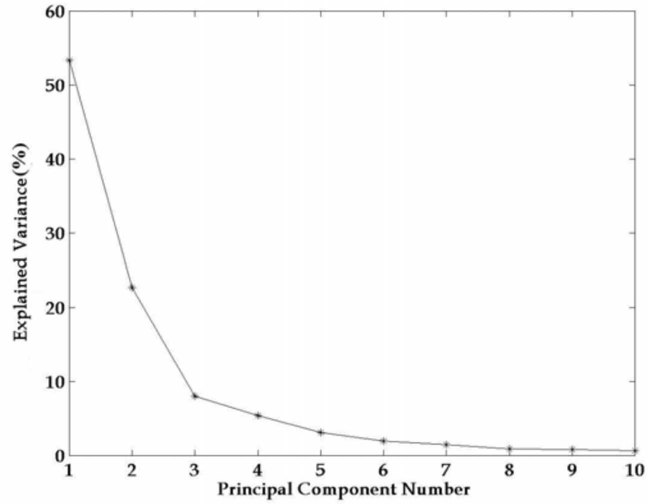

Fig. 3. Explained variance of the first ten principal components for the summer air surface temperature time series. Only the two first components were retained because the difference in the explained variance between the third and the fourth components was only 2.6.

In order to identify the potential predictors for the seasonal ASTA principal components described before, the cross correlation function was calculated between these components (dependent variable) and the three index preceding seasons (independent variable, Fig. 4), retaining only those with significance greater than the 95% level (Ebisuzaki, 1997). After that, a multiple regression model was optimized using a forward stepwise routine, between the ASTA principal component and the potential seasonal predictor indices identified previously. At first, the model was considered good if its *F*-statistic was greater than 4, the multiple R was greater than 0.4 and the *p*-values of the coefficients were less than 0.05 (*t* values greater than 2).

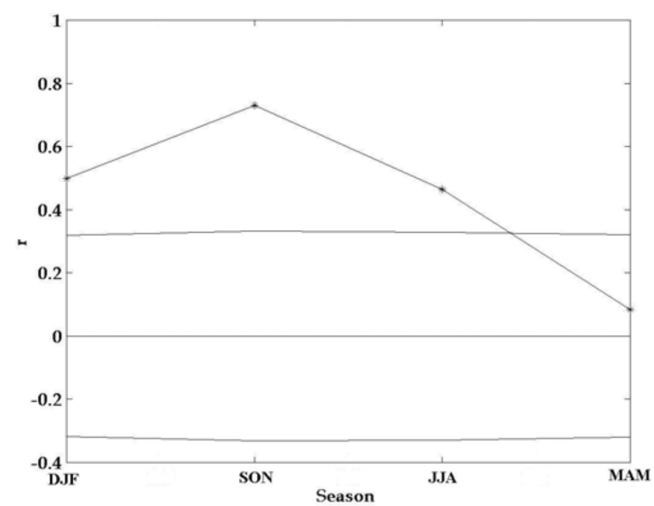

Fig. 4. Cross correlation function, line with asterisks, between the first winter surface temperature principal component and the three preceding seasons of the ENP index. The solid lines are the 95% significance level. This figure identifies the preceding index's autumn and summer as potential predictors.

Once the models were adjusted, their forecasts were cross validated (Wilks, 1995; Ward and Folland, 1991), and were evaluated using several categorical scores for three categories: Above Normal (AN), Normal (N) and Below Normal (BN). Those scores include:

Hit Rate (HR): Is the percentage of the *n* forecasting occasions when the categorical forecast correctly anticipated the subsequent event.

Skill Score (SS): It is an adjustment of the HR. SS has a chance value of 0, a score of +100% for a set of perfect hits and a score of –100% for a set of forecast with no hits. The transformation is SS = 100 x (HR-C)/(100-C), where C = 33.3%: the chance hit rate for this study.

Linear Error in Probability Space (LEPS) Score: LEPS operates similar to the SS, but penalizes a forecast that is two categories in error more than a forecast that is one category in error. Each forecast scores points following the table:

		Forecast Tercile		
		Below	*Normal*	*Above*
	Below	$+1.35$	-0.15	-1.20
Observed	*Normal*	-0.15	$+0.30$	-0.15
Tercile	*Above*	-1.20	-0.15	$+1.35$

The table is defined so that a random forecast has an average score of zero. Then, LEPS skill score is calculated as

LEPS = 100 x (∑ Points scored) / (∑ Points scored by a set of perfect forecast)

Probability of detection (POD) above and below normal: Is the percentage of those occasions when the forecast event occurred on which it was also forecast.

False alarm rate (FAR) above and below normal: Is that percentage of forecast events that fail to materialize.

Also, the Skill (S) of those models was included, calculated as the correlation between the forecasted data and the observed data. A model was considered good if the SS and LEPS were positive, the PODs were greater than 50% and its FARs were lees than the 33.33%.

Finally, the linear trend was removed from the low ATSA filtered data and their non-rotated EOFs were correlated with the first three unrotated global SSTA modes used in Enfield and Mestas-Nuñez (1999) and the first six rotated global SSTA modes of Mestas-Nuñez and Enfield (1999) in order to identify some plausible relationships between oceanic climatic variations and the Central American ASTA in the decadal scale.

3. Results and Discussion

3.1 Annual Cycle and trend

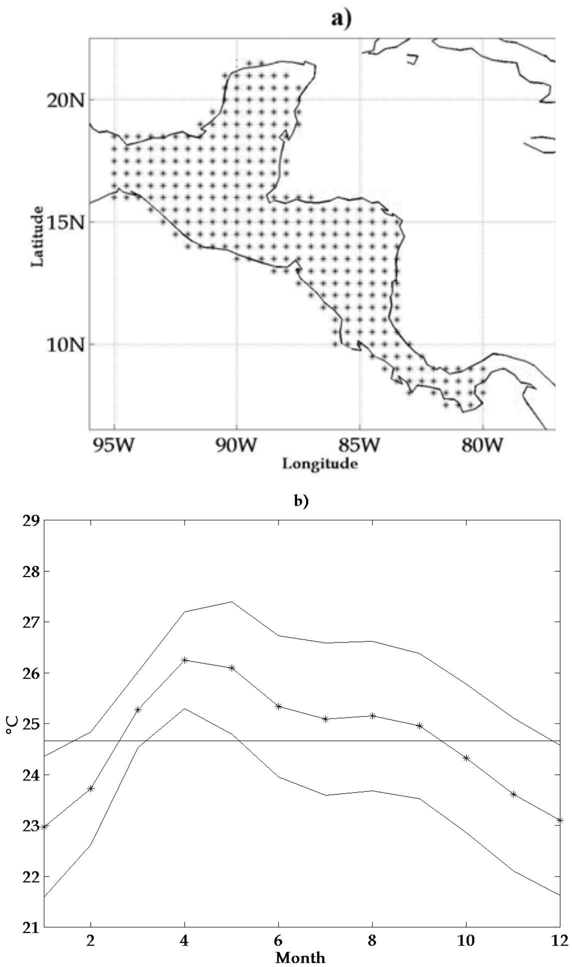

Fig. 5. a) Grid points associated to the first (asterisks) principal component of the mean annual cycle. b) The line with asterisks are the mean annual cycle of the grid points associated to the first principal component plotted in a). The upper and lower solid line is one standard deviation. The horizontal line is the annual mean of 24.7 °C.

The mean AST annual cycle in the region is described by one principal component that explains 80.43% of the variance (Fig. 5), this result aggress with Portig (1976), who also distinguished one type of dominant annual cycle in the region. This cycle is described by Portig like a monsoon type, with the highest temperatures before the summer rains, has a minimum during January, mainly associated to strong trade winds and a maximum during April, associated with a decrease in magnitude of the trade winds and a low (high) values in cloud covertures (radiation) (Fig. 6). It is noticeable a second temperature minimum around July, which is also the period of the Mid Summer Drought (Magaña *et al.*, 1999), in which the magnitude of the trade winds increases again, there is a second minimum (maximum) in cloud covertures (radiation), and there is also the appearance of a low level jet over the region (Amador, 1998; Amador *et al.*, 2000). It is noticeable that, at this

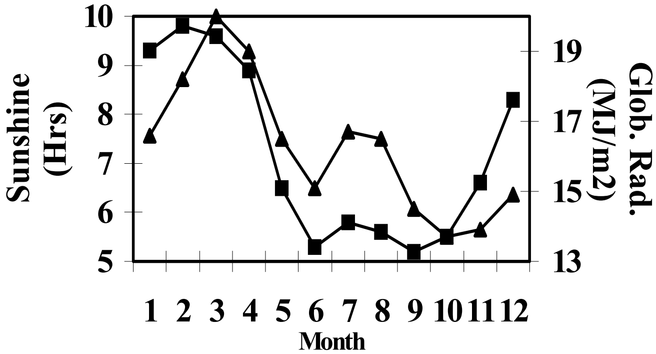

Fig. 6. Annual Cycle for Sunshine hours, line with squares, and total Radiation, line with triangles, for the Liberia station (10° 36'N, 85° 32'W, from Alfaro (1993), period used 1968-90 and 1970-76, respectively). The annual average values for these two variables are 7.2 hrs and 16.3 MJ m^{-2}, respectively.

resolution of the data, there is not an evident division between the shape of the curve for climates in the Pacific and Caribbean slope, as has been noticed previously for other atmospheric variables (Alfaro, 1993).

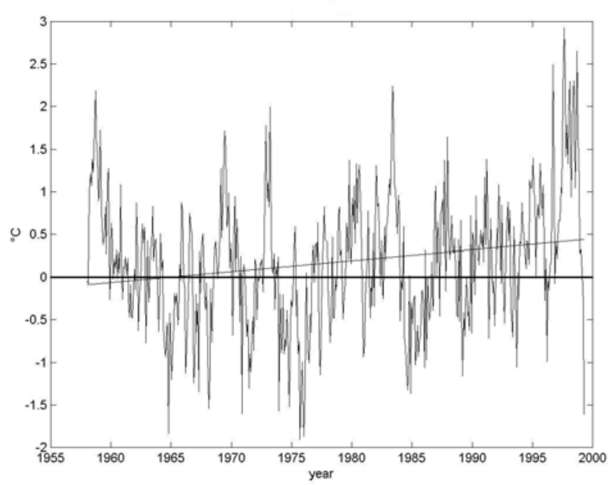

Fig. 7. Mean air surface temperature anomalies of the grid points show in Fig. 1. The solid line, with positive slope, is its linear trend that is statistically significant at the 95% level.

The secular trend of the region is presented in the Fig. 7, taking as the average of the ASTAs of the grid points in the Fig 1. There is noticed a significant positive trend in the region that was also identified in some previous studies (e.g. Araya *et al*., 2000) and that agrees with the trend pattern of the global temperatures (Mann, 1999).

3.2 Seasonal Models

The results of the principal component analysis for the seasonal ASTA series are shown in Table 2. It is noticed that, according to the methodology described in section 2, were retained two principal components in all the seasons that explain together between 74 and 80 of the explained variance.

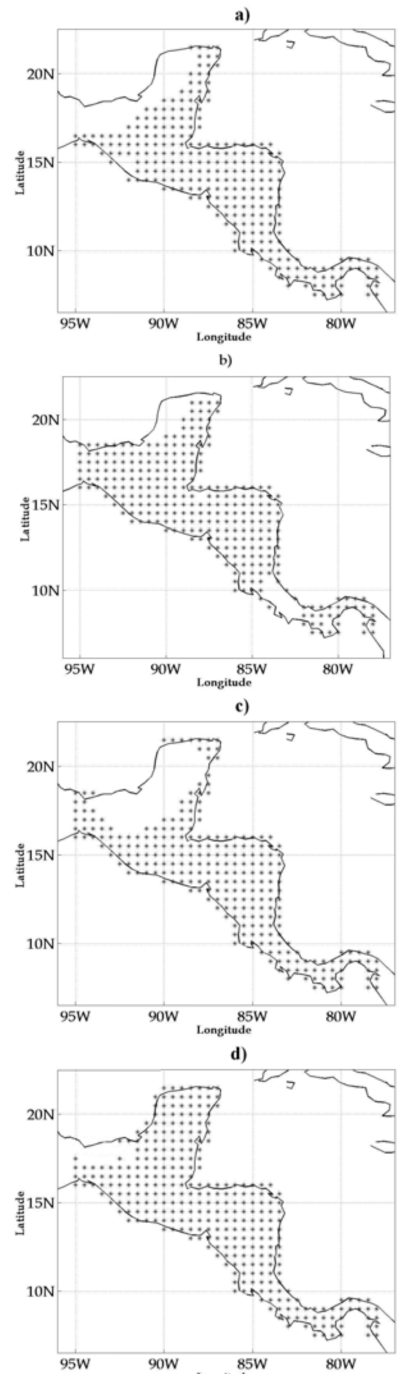

Fig. 8. Grid points associated to the first (asterisks) principal component for: a) winter, b) spring, c) summer and d) autumn.

Table 2. Number of principal components preliminary retained and their percentage of explained variance for the different air surface temperature seasons.

	Season			
Number of Principal component	**Winter**	**Spring**	**Summer**	**Autumn**
1	58.5	56.6	53.4	62.7
2	21.5	17.4	22.7	13.6
Total	**80.0**	**74.0**	**76.1**	**76.3**

In general, taking the percentage of variance explained for each component in every grid data point as a grouping variable for the seasonal ASTAs, it was noticed that, as in the annual cycle, the first principal component dominates in the isthmus except in regions near the Tehuantepec Isthmus and Yucatan Peninsula (Fig. 8).

In order to help the correct interpretation of the relationships found between the seasonal Principal Components and the climatic variable, ASTA indices were calculated as the average of the grid points in which the explained variance, associated to a particular Principal Component, was maxima. Those points are plotted in Fig. 8. The correlation coefficient between the index and the Principal Component was calculated after that, all of them were positive and greater than 0.98.

The models adjusted for the air surface temperature are shown in Table 3. It is noticeable that were fixed models for the first component for all seasons, which is important because this component dominates most of the region. All this models showed positive correlation with previous ENSO indices seasons, mainly with the Niño 4 index. Similar results were found in a recent study for power generation in Costa Rica (ICE, 1994). It was found not predictability scheme for any of the second seasonal ASTA principal components.

Alfaro and Lizano (2001) showed that events in the eastern tropical Pacific correlate positively with the SSTAs in several areas of the Central American Pacific. This explains the positive correlation in all temperature models and also explains the positive correlation found between the first autumn and winter principal component and the ENP index. This shows that a bigger (smaller) size of the warm pool in the Central American Pacific side influences positively (negatively) the air surface temperature in almost all the region. This is mainly the result of latent and sensible heat transfer from the ocean to the atmosphere. The same mechanisms could explain the influence of the TNA. This influence was smaller over the region, because it was noticed only that previous spring index season showed positive correlations with the first summer principal component.

Taylor *et al.* (2001) and Enfield and Mayer (1997) explain that this is because the relation between Niño 3 and TNA is stronger during the boreal winter-spring. They described that Niño 3 SSTAs, a few months prior, are primary contributors to the warmings or coolings of the TNA SSTAs during spring. Hence the equatorial Pacific can alter Central American ASTAs also indirectly through its effect on the TNA.

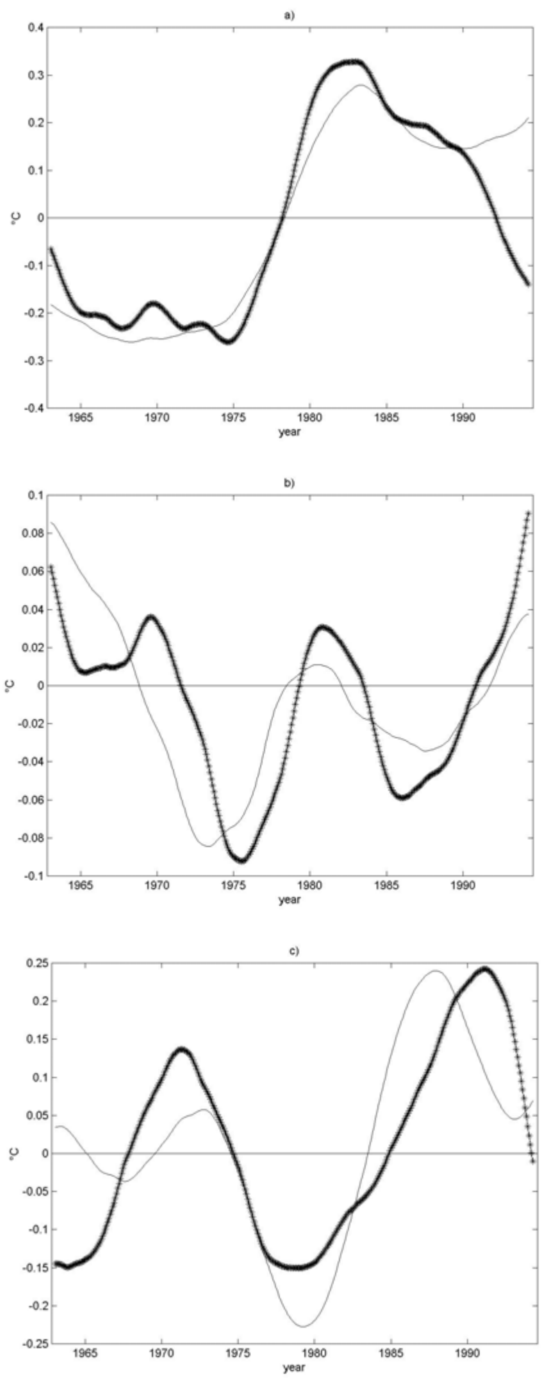

Fig. 9. First three ASTA modes (line with asterisks) and the three global SSTA modes (continuous line) that show the main correlation with the first ones: a) T1 and R3, b) T2 and R2, c) T3 and R6. The scale in the y-axis was modified for comparative proposes.

Table 3. Models fixed between the First Principal Component of the seasons for the air surface temperature field and the preceding seasons of the indices used. It was used Sp for Spring, Su for Summer and A for Autumn. ENP is the index for the eastern nort h Pacific West Hemisphere Warm Pool (Wang and Enfield, 2001).

Season	Model	R	S	LEPS	HR	SS	POD(BN)	POD(AN)	FAR(BN)	FAR(AN)
Autumn	PC1 = 0.37 + 17.05 Su-Niño4 + 10.97 Su-ENP	0.73	68.34	60.47	81.25	71.88	70.00	72.73	10.00	0.00
Winter	PC1 = -0.66 + 11.92 Sp-ENP + 9.40 Sp-Niño4	0.78	73.50	62.34	81.25	71.88	80.00	63.64	0.00	0.00
Spring	PC1 = -0.27 + 9.20 A-Niño3	0.61	56.84	40.31	71.88	57.81	60.00	54.54	10.00	9.09
Summer	PC1 = 0.73 + 13.43 Sp-ATN + 14.61 Sp-Niño4	0.80	74.70	60.47	81.25	71.88	70.00	72.73	10.00	0.00

3.3 Relationships between the low filtered Central American ASTAs and the tropical Atlantic and Pacific oceans' decadal variability

Only the first three unrotated EOF ASTA modes, of the detrend-low filtered data, showed some significant and non redundant relationships with those global SSTs modes used for Enfield and Mestas-Nuñez (1999) and Mestas-Nuñez and Enfield (1999). These three precipitation modes explain 41.3, 29.2 and 14.0% of the variance, that is, around 84.5% of the total low filtered air surface temperature variance of the region. The modes' correlation is presented in Table 4. Fig. 9 shows the three ASTA modes and the three global SSTA ones that show the main correlation with the first ones. As in the previous section, the correlation coefficient between the ASTA index and the correspondent EOF was obtained. All the correlations were positive. This means that a positive (negative) correlation between any ASTA mode and any SSTA mode means a positive (negative) correlation between the correspondent ASTA index and the same SSTA mode.

Table 4. Correlations between the first three leading modes of the low filtered ASTAs in Central America and the first three (six) non-ENSO unrotated (rotated) global SSTA modes defined by Enfield and Mestas-Nuñez (1999) and Mestas-Nuñez and Enfield (1999). Italic values are significant at the 95% level according to Ebisuzaki (1997).

		Central America Air Surface Temperature Modes		
		T1	**T2**	**T3**
	U1	*0.742*	0.467	-0.186
Global	**U2**	-0.182	0.445	0.55
SST	**U3**	-0.757	0.1	-0.48
Modes	**R1**	-0.022	*0.665*	-0.37
	R2	0.044	*0.69*	-0.376
	R3	*0.91*	0.026	0.168
	R4	0.461	*0.631*	0.166
	R5	*-0.846*	0.273	0.321
	R6	0.092	-0.157	*0.738*

The first air temperature mode, T1, has significant and positive correlations with the U1, Pacific interdecadal variability and R3, eastern tropical Pacific interdecadal variability. There is also a significant and negative correlation with R5, North Pacific multidecadal variability (Table 4). According to Enfield and Mestas-Nuñez (1999), U1 mode is associated with the 500 hPa pressure height mid tropospheric pattern of the Pacific North American (PNA). Meanwhile, Mestas-Nuñez and Enfield (1999) explained that R3 captures interdecadal SSTA changes in the eastern tropical Pacific that modulate the interannual ENSO. These SSTA changes induce changes in the equatorial Walker circulation that force westward winds in the central equatorial Pacific. R5 captures different aspects of the Pacific interdecadal variability related to the PDO and that is consistent with local atmospheric forcing. This Pacific influence in the decadal scale is consistent with the results of the Table 5 which shows the correlations between some of the different low filtered climate variability indices, that are related with climate variability in Central America (e.g. Wang and Enfield, 2001; Enfield, 1996 and Waylen *et al*., 1996), and the ASTA unrotated modes. The time period used to calculate the correlations was the same of the low filtered ASTA time series (1963-1994).

Table 5. Correlations between the first three leading modes of the low filtered ASTAs in Central America and different tropical climate variability indices. Italic values are significant at the 95% level according to Ebisuzaki (1997). ENP and IAS are the indices for the eastern north Pacific and the Intra-Americas Sea West Hemisphere Warm Pool, respectively (Wang and Enfield, 2001).

		Central America Air Surface Temperature Modes		
		T1	**T2**	**T3**
	Niño 1&2	*0.837*	0.027	-0.156
Climate	**Niño 3**	0.742	0.487	0.1
Variability	**Niño 3.4**	0.54	*0.683*	0.089
Indices	**Niño 4**	0.45	*0.62*	0.359
	SOI	-0.707	-0.462	-0.116
	ENP	0.542	0.383	0.524
	IAS	0.485	*0.538*	0.478
	TNA	0.337	*0.752*	-0.207
	TSA	0.323	-0.158	*0.716*

From Table 5, we noticed that T1 has high positive correlation with SSTA indices in the eastern Pacific: Niño 1&2 and Niño 3, and also a negative correlation with SOI. Also, correlations between U1/R3 and the eastern Pacific indices are positive and negative with SOI, meanwhile there is a high and negative correlation between the Niño 1&2 and R5. This means that U1, R3 and R5 are highly correlated with the non-ENSO decadal variability in the eastern tropical Pacific. So, those indices influence the AST in Central America in a similar way to that described by Mestas-Nuñez and Enfield (2001) for the low-pass component of Niño 3 region. They described that on decadal scales, the ENSO and the residual variability show similar patterns for SST, SLP and surface wind stress, this means that warm (cold) SSTA events in the decadal scale are positive correlated with warm (cold) ASTA events in Central America.

The second air temperature mode, T2, has significant and positive correlation with: R1, North Atlantic multidecadal variability, R2, Eastern North Pacific interdecadal variability and R4, Central tropical Pacific interdecadal variability (Table 4). R1 captures multidecadal fluctuations in the North Atlantic consistent with local atmospheric forcing related to the NAO. R2 captures interdecadal fluctuations in the eastern North Pacific related to local atmospheric forcing through surface fluxes and upwelling along the coast of North America and R4 captures different aspects of the Pacific interdecadal variability in a similar way of R5 (Mestas-Nuñez and Enfield, 1999). Table 5 shows that T2 has significant and positive correlations with TNA, IAS, Niño 3.4 and Niño 4 indices. R1, R2 and R4 have high and positive correlations with TNA, and also R4 has a high and positive correlation with IAS. So these relationships suggest that decadal variability in these SSTA modes modulates in some way the local heat transfer from the ocean to the overlaying atmosphere in the TNA region. Also, this Atlantic variability, in the decadal scale, has some modulation on the frequency of hurricanes that is an important feature of the regional climate (Goldenberg *et al*., 2001). On the other hand, R4 shows significant and positive correlations with almost all the indices in the tropical Pacific and a negative correlation with SOI. Also R2 has a positive correlation with Niño 3.4. These results suggest that R2 and R4 modulate T2 in a similar way that U1, R3 and R5 modulate T1, but the main difference is that T2 looks to be correlated more with variations in the tropical central Pacific and T1 with variations in the tropical eastern Pacific.

According to Table 4, the third mode, T3, shows significant and positive correlation with R6, South Atlantic interannual variability, what is related to interannual changes in the South Atlantic and is consistent with the surface pressure pattern as a response to atmospheric forcing, but Mestas-Nuñez and Enfield (1999) noticed that winds results are not consistent with the previous pattern. This relationship between T3 and R6 agrees with the significant and positive correlation between T3 and TSA (Table 5). The remote modulation of this oceanic region is not clear but both T3 and R6 have negative and significant correlations with the TNA-TSA indices difference of -0.67 and –0.82 respectively, so it could be speculated that this remote relationship could be through inter-hemispheric anomaly SLP patterns in the tropical Atlantic atmosphere.

4. Summary

The Central American air surface temperature showed homogenous variations in two important aspects: the annual cycle and the seasonal variations. These variations were explained mainly by the first principal components (Figs. 5 and 8). The region also shows a clear positive trend that is in agreement with the global temperature pattern that supports the idea of global warming.

The models fixed showed that the ENSO indices, Niño 3 and 4, have the largest influence over the region when compared with the influence of the other indices, having positive correlation with all the first surface temperature principal components. This explains more than the 53% of the variance in the region. Also, in spite that the Skills of the models fixed in Table 3 are high (> 0.6), the methodology is recommended for its use in a categorical way for climate predictions. In this aspect, the analysis of the categorical scores showed predictability potential, because they had high probability of detection and low false alarm rate scores.

In the decadal scale, the first mode of the ASTAs looks to be related with the eastern tropical Pacific, the second mode with the tropical north Atlantic and the central tropical Pacific and the third mode with the tropical south Atlantic (Table 5).

The results of these regression models in Table 3 and the correlation analysis of Tables 4 and 5, suggest that in general eastern Pacific (mainly) and Atlantic variability in both interannual and decadal scales, has a clear positive influence over the air surface temperature in Central America, in which warm (cold) SSTA events are correlated with warm (cold) ASTA events. This remote or local connection could be active through several processes like the modulation of the size and SSTs magnitude of the warm pool near Central America or by inducing some anomalous troposphere patterns (e.g. PNA or wind shear). The first process affects the sensible and latent heat transfer from the ocean to the atmosphere and the second could alter the seasonal behavior, directly or through feedback processes, of some atmospheric variables like SLP, surface wind and precipitation that are related with the air surface temperature in the region.

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Resumen.

Para este estudio se utilizaron 337 puntos de una rejilla (0.5 ° de latitud x 0.5° de longitud), sobre el istmo centroamericano, de un conjunto de datos mensuales de Temperatura Superficial del Aire. A estos datos se les removió, el ciclo anual, la tendencia y la componente decadal y se calcularon las series de tiempo para las distintas estaciones climáticas del año. Posteriormente se ajustaron modelos de regresión múltiple entre las primeras componentes principales de este campo (variables dependientes) y diversos índices de Temperatura Superficial del Mar (variables independientes). Se pudieron ajustar modelos predictivos para todas las primeras componentes principales de las cuatro estaciones del año. Estos modelos mostraron que la principal influencia sobre la región, al compararla con los otros índices, la ejerce el fenómeno de El Niño-Oscilación del Sur (ENOS), pues mostró correlaciones positivas con todas las estaciones climáticas del año de la temperatura superficial, lo cual refleja una transferencia de calor sensible y latente desde el océano a la atmósfera suprayacente. Todos los modelos anteriores presentaron porcentajes de detección siempre arriba del 50% y porcentajes de falsas alarmas menores al 10%. En la escala decadal, la temperatura en Centroamérica presentó relaciones similares con los océanos Atlántico y Pacífico tropical pues mostró correlaciones positivas con ambas regiones oceánicas.

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