14th Symposium on Global Change and Climate Variations, 83rd Annual Meeting of the American Meteorological Society, 9 - 13 February, 2003, Long Beach, California

P3.19 INTERANNUAL AND INTERDECADAL VARIABILITY IN THE PREDOMINANT PACIFIC REGION SST ANOMALY PATTERNS

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1. INTRODUCTION

The interactions between the atmosphere and oceans are important processes to consider when attempting to either understand the relevant physics of the earth's climate system or make a long-range forecast. The atmosphere and oceans are two important components of the climate system that are considered to be thermodynamically open (they exchange both heat and mass) (e.g., Piexoto and Oort 1992).

It is well known that SST anomalies have a large impact on the weather and climate by changing heat and mass distributions of the troposphere. Through this influence, SSTs can alter the prevailing wind patterns over a large portion of the globe (e.g., Namias 1982, 1983; Hoskins et al. 1983; Keables et al. 1992; Nakamura et al. 1997; Renwick and Revell 1999). This in turn can impact on the frequency, occurrence, and intensity of such phenomena as mid-latitude cyclones (e,g,, Key and Chan 1999) and blocking anticyclones (e.g, Wiedenmann et al. 2002).

Kung and Chern (1995) used principal component analysis to extract the large-scale modes of monthly mean global SST anomalies and the Northern Hemisphere tropospheric circulation anomalies during the period 1955 – 1993. Such a technique provides an archive which can be used for long-range forecasting applications (e.g., forecasting using analogs). A by-product of this analysis demonstrated that global SST anomalies can be classified into one of seven distinct pattern types of anomaly distributions (A – G). Each of these was correlated with corresponding Northern Hemisphere tropospheric flow anomalies. Kung and Chern (1995) also noted that anomaly types (clusters) A,B, E, and G (C,D, and F) are representative of La Nina or neutral (El Nino) type SST distributions within the Pacific Ocean basin. They also demonstrated that clusters A-D dominate the early portion of their study period (1955 – 1977), while E and F type clusters dominate the latter portion. G-type SST anomalies were comparatively rare in either period.

The goal of this work is to extend this study to include the period 1947 – present. In extending the Kung and Chern (1995) study, this work will demonstrate that the interdecadal variability noted above may be related to the Pacific Decadal Oscillation (PDO) (e.g., Gershunov and Barnett 1998). This work will also demonstrate that these SST types can be used for long-range forecasting applications in the Midwestern United States.

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2. ANALYSES AND METHODS

2.1 Analyses

The analyses used in this study were the global monthly mean extended and reconstructed SSTs and SST anomalies compiled by the National Centers for Environmental Prediction (NCEP) and available through the National Oceanic and Atmospheric Administration (NOAA) online archive[1]. Monthly SSTs and anomalies are available from 1864 to the present time, and these can also be found in the monthly Climate Diagnostics Bulletin (Kousky 2002). The 500 hPa heights and height anomalies from the NCEP re-analysis project (Kalnay et al. 1996) were also examined and are available via the same sources referenced above.

2.2 Methods

For each month, visual inspection of the monthly SST and 500 hPa height charts was shown to be a reliable method for classifying the SST anomaly distributions into one of seven different synoptic categories (A – G) as defined in Kung and Chern (1995). In order to be certain that this method was reliable, visual inspections of monthly mean SST anomalies for randomly chosen months within the period of study of Kung and Chern (1995) were carried out in order to verify that observations by this group matched those of Kung and Chern (1995). Manual inspection was also used by Kung and Chern (1995) after they used the clustering method of Fukunaga (1972) to derive seven distinct anomaly types.

[1] wesley.wwb.noaa.gov/ncep_data/index_sgi62_png.html

3 SYNOPTIC ANALYSIS OF GLOBAL SSTs

In Fig. 1, examples of the seven different SST anomaly clusters are shown. These monthly SSTs are not the same months shown in Kung and Chern (1995), but were classified similarly to those found in their Fig. 1. The characteristics of each type of anomaly are described in their paper, and the accompanying tropospheric height anomalies are also shown and described.

Briefly, SST clusters B and G are representative of strong La Nina type clusters in the Pacific Ocean basin. These are also characteristic of opposing SST anomaly distributions in the Atlantic Ocean Basin. Clusters A and E are characteristic of weak La Nina to ENSO Neutral type conditions. These SST anomaly distributions are similar in each major ocean basin, with the exception that E-type anomalies are associated with more widespread coverage of warm anomalies. The remaining clusters are C, D, and F type anomalies, which are representative of El Nino-type SST distributions in the Pacific Ocean basin. The D-type cluster represents fairly weak ENSO conditions, while C and F type anomalies represent strong El Nino conditions. C and F type anomalies are also similar to each other with the exception that F type anomalies are associated with more widespread coverage of warm anomalies especially in the North Pacific and Atlantic Ocean basins.

Table 1 was reproduced from Kung and Chern (1995) and then extended from January 1994 – present (Aug. 2002 at the time of this writing). The initial results show that following 1993, there was an extended period of E-type anomalies (34 months, 2nd longest in the record), which correspond to the extended period of ENSO neutral conditions during the mid-1990’s (Table 2). This compares to the extended period (39 months, longest in the record) of B-type anomalies which were characterized by La Nina and ENSO neutral conditions during the mid-1970s. This extended period of B-type anomalies was bookended by mostly C-type anomalies representing the 1972 and 1976 El Ninos.

The strong El Nino of 1997 was characterized by the presence of F-type anomalies, and this El Nino was similar in character to the strong El Nino events of 1982 and 1986 - 1987. These El Nino events were also predominated by F-type SST anomalies, athough a few C-type anomalies were associated with the 1982 El Nino. Thus, all the El Nino events that occurred during the period 1977–1998 were characterized by the presence of primarily F-type anomalies. This contrasts with the earlier period (1955-1976) when El Nino events were dominated by C and D-type anomalies (Tables 1, 2).

Then, during the latter part of 1998 through early 2002, the occurrence of G-type anomalies was prominent, but these were interspersed with the occasional period of A or B type anomalies. The occurrence of G-type anomalies accompanied the La Nina years of 1998 and 1999 and the neutral conditions thereafter. Until the recent re-emergence of these G-type anomalies, this SST type was not observed to occur often in the Kung and Chern (1995) analysis. In their analysis, these G-type anomalies were associated with La Nina and ENSO neutral years.

This work suggests that the re-emergence of the G-type anomalies may be associated with a change in the phase of the PDO (Table 3). As early as the latter months of 1999 (e.g., Kerr 1999), it was suggested that a change in phase of the PDO was underway. More recent publications have also suggested a change in phase of the PDO of late, including the scientific report of the IPCC (2001). Just as the occurrence of the predominant SST anomalies changed from E and F type to G, A, and B-type during 1998 and 1999, there was the earlier change noted by Kung and Chern (1995) around 1977 (see section 1 here). The change they noted in predominant SST type also matches a change in the phase of the PDO (Table 3). Thus, this simple analysis may capture the change in phase of the PDO. This conclusion is further bolstered by the late onset of D-type anomalies (June, July, and August, 2002, which correspond to the recent return of El Nino[2].

[2]http://www.noaa.gov or see the Climate Diagnostic Bulletin ENSO indicies

Table 1. The monthly classification of global SSTs from 1955 – August 2002. The classifications from 1955 – 1993 are adapted from Kung and Chern (1995).

Year	J	F	M	A	M	J	J	A	S	O	N	D
1955	A	A	A	A	A	A	A	A	A	G	G	G
1956	A	A	A	A	A	A	A	A	A	G	G	G
1957	G	A	A	A	A	F	F	F	F	F	F	D
1958	D	D	D	D	D	D	F	F	F	D	D	D
1959	D	D	D	D	D	D	A	A	A	A	A	A
1960	A	A	A	A	A	A	D	A	A	A	G	A
1961	A	A	A	A	A	A	A	A	A	A	G	G
1962	G	G	G	G	G	G	G	D	G	G	G	G
1963	A	A	D	D	D	D	D	D	D	D	D	D
1964	D	D	A	D	A	A	A	G	G	G	A	A
1965	A	A	A	A	A	A	A	F	F	F	F	F
1966	D	D	D	D	D	A	A	A	A	D	D	D
1967	A	A	A	A	A	A	A	A	A	A	A	A
1968	A	A	A	A	A	A	A	F	F	F	D	D
1969	D	D	D	D	D	F	D	E	E	E	D	D
1970	C	C	C	C	C	C	C	B	B	B	B	B
1971	B	B	B	C	B	B	B	B	B	B	B	B
1972	B	B	B	C	C	C	C	F	C	C	C	C
1973	C	C	C	B	B	B	B	B	B	B	B	B
1974	B	B	B	B	B	B	B	B	B	B	B	B
1975	B	B	B	B	B	B	B	B	B	B	B	B
1976	B	B	B	B	B	B	B	C	C	C	F	F
1977	C	C	C	B	B	E	E	E	E	E	C	F
1978	F	F	F	E	E	B	C	E	E	C	F	F
1979	C	C	C	C	C	C	F	F	F	F	F	F
1980	F	F	F	F	F	E	E	E	E	E	E	E
1981	F	F	F	C	C	E	E	E	E	E	E	E
1982	E	E	E	E	C	F	F	C	C	C	C	F
1983	C	F	F	F	F	F	F	E	E	C	E	E
1984	E	E	F	B	E	B	E	E	E	E	B	B
1985	B	B	B	B	B	E	E	E	E	E	E	E
1986	E	E	F	E	E	F	F	F	F	F	F	F
1987	F	F	E	E	F	C	F	E	F	E	F	F
1988	E	E	E	E	E	E	E	E	E	A	A	G
1989	G	G	G	G	F	F	E	E	E	E	F	F
1990	A	E	E	F	F	F	F	F	D	D	D	D
1991	D	F	F	C	C	E	E	E	E	F	F	F
1992	F	F	F	F	F	F	F	F	F	F	F	F
1993	F	F	F	F	F	F	F	F	D	F	F	F
1994	D	D	F	E	F	F	D	E	D	D	D	D
1995	E	E	E	E	E	E	E	E	E	E	E	E
1996	E	E	E	E	E	E	E	E	E	E	E	E
1997	E	E	E	E	E	E	E	E	E	E	F	F
1998	F	F	F	F	F	F	F	G	G	G	G	G
1999	G	G	G	G	G	G	G	G	G	G	G	G
2000	G	G	B	B	B	G	G	A	A	A	A	G
2001	G	B	B	B	G	G	G	G	G	A	A	A
2002	B	A	A	A	A	D	D	D				

4. SUMMARY AND CONCLUSIONS

Using monthly mean SST and 500 hPa height data routinely available via the internet or regular monthly publications, the SST anomaly classification archive initiated by Kung and Chern (1995) for the period 1955 – 1993 was updated to include all months up to August of 2002. Careful manual inspection on the SST anomalies and selected 500 hPa height anomalies was performed in order to verify that this analysis agreed with those of Kung and Chern (1995). Then the months from January 1994 to August 2002 were examined and classified. The next phase of this project is to extend the analysis back to 1947, and determine whether there is a correlation between monthly SST anomalies for each cluster and mid-western monthly temperature and precipitation anomalies. Standard statistical testing will also be performed in order to determine if any of these correlations are significant at standard levels of confidence.

The initial results validate the conclusions of Kung and Chern (1995), in that SST clusters A, B, E, and G (C, D, F) are representative of La Nina or neutral (El Nino) conditions within the Pacific Ocean basin. These results also provide strong circumstantial evidence that certain classes of SST anomalies could be associated with distinct phases of the PDO, and, thus, changes in the phase of the PDO were associated with changes in the predominant SST modes. In particular, the period 1955-1976 was dominated by SST types A – D, while the period 1977 – 1998 was associated with the occurrence of E, F, and occasional C modes. The most recent period has been predominated by G, A, and B modes. Finally, the most recent three months have marked the return of El Nino and have been associated with D-type anomalies. Thus, this most recent El Nino event is closer in character to El Nino events of the 1955-1976 period rather than the El Nino events of the 1977 – 1998.

Table 2. A list of years examined in this study separated by ENSO phase (ENSO definition found at www.coaps.fsu.edu).

La Nina (LN)	Neutral (NEU)	El Nino (EN)
1949	1945-1948	1951
1954	1950	1957
1955	1952-1953	1963
1956	1958-1962	1965
1964	1966	1969
1967	1968	1972
1970	1974	1976
1971	1977-1981	1982
1973	1983-1985	1986
1975	1989-1990	1987
1988	1992-1996	1991
1998-1999	2000	1997

Table 3. The phase of the Pacific Decadal Oscillation (PDO) (adapted from Gershunov and Barnett, 1998).

PDO Phase	Period of Record
Phase 1	1933 - 1946
Phase 2	1947-1976
Phase 1	1977 - 1998
Phase 2	1999 - present

5. ACKNOWLEDGEMENTS

The authors would like to thank Dr. Ernest C. Kung for his contribution in discussing these results.

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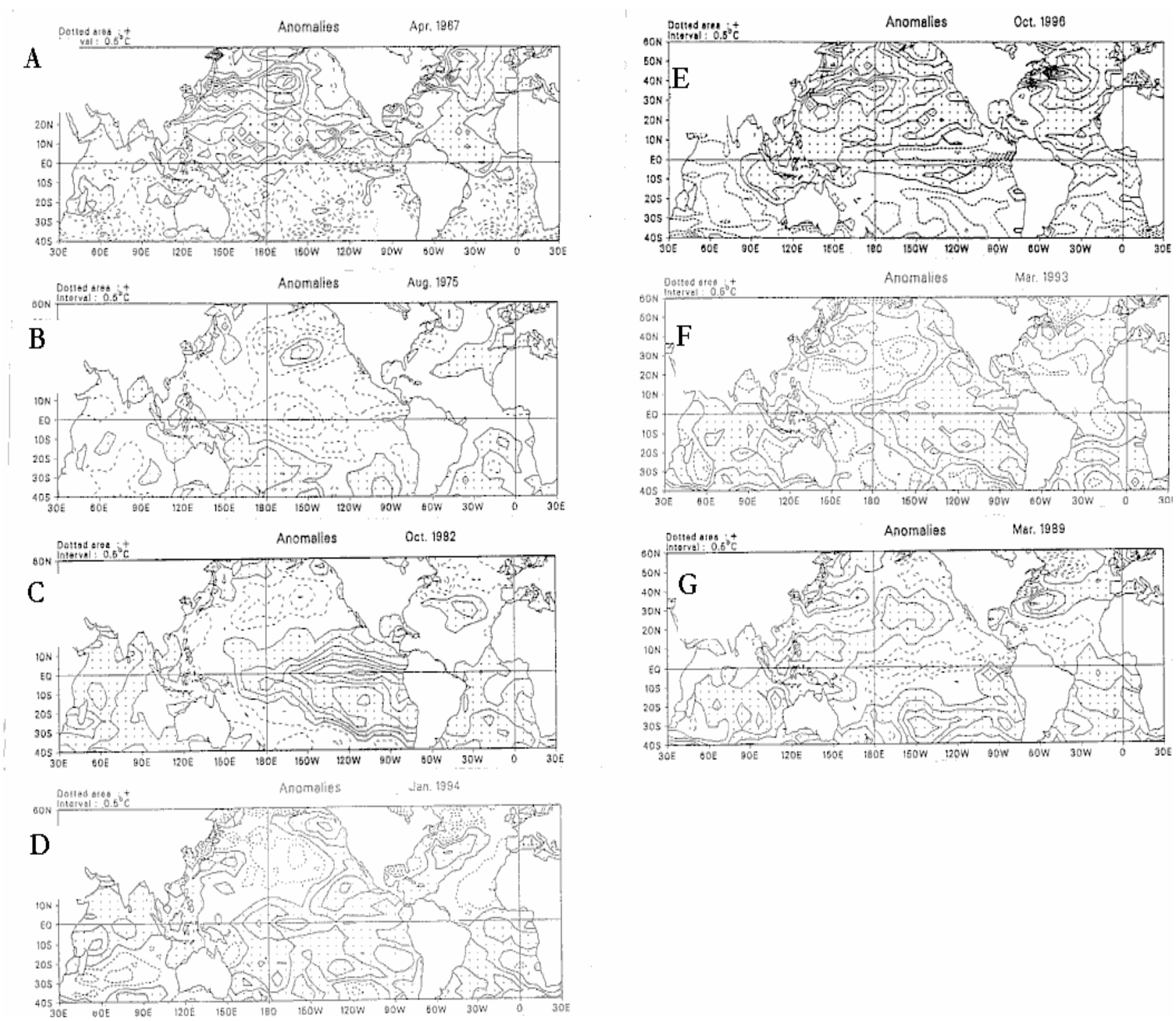

Figure 3. The seven identified types of SST (A-G) anomalies from Kung and Chern (1995).