Pacific Decadal variability and decadal ENSO amplitude modulation

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1. Introduction

Several recent studies have suggested the existence of Pacific Decadal Variability (PDV) and its possible impacts on the global climate (Mantua et al., 1997). Proposed physical mechanisms for explaining the PDV can be separated into three broad categories: (i) tropical-extratropical interactions (there are several different possible mechanisms for these interactions) (e.g., Gu and Philander, 1997), (ii) purely tropical processes(e.g., Knutson and Manabe, 1998) and (iii) purely extratropical processes (e.g., Kleeman et al., 1999). Despite this wealth of potential mechanisms, it still remains unclear whether the PDV drives low frequency modulation of the El Niño and Southern Oscillation (ENSO) amplitude and frequency (Kirtman and Schopf, 1998). There is no consensus on the relationship between decadal modulation of ENSO amplitude and the decadal background state of the tropical Pacific. Our purpose is to investigate whether PDV is associated with low frequency modulation of ENSO amplitude. The analysis described in this paper is primarily based on the first two Empirical Orthogonal Functions (EOFs) over the Pacific (60N-30S, 120E-270E) and an index of ENSO amplitude variations. Monthly sea surface temperature anomalies (SSTAs) are from the gridded dataset of Kaplan et al. (1998) for the period of 1900-2001. Monthly mean SSTAs were determined by removing the 1950-1980 climatological monthlymeans. An EOF analysis is applied to the detrended and lowpass (Period > 8 years) filtered Pacific SSTA in order to isolate the decadal variability. We used a 8-year running mean to obtain decadal SSTA variability. Note that modifying the averaging periodhas little qualitative impact on the results. The time series of a 8-year running mean of the NINO3.4 (5N-5S, 170E-240E) amplitude (hereafter, N34Var).

2. Results

We first begin by showing the first two EOFs of Pacific decadal SST variability, i.e., PDV1 and PDV2 (Figs. 1a,b).The PDV1 (PDV2) explains 36.2 (25.2) % of the filtered variance. In contrast to PDV1, the warm anomalies of PDV2 are trapped in the eastern and central tropical Pacific and there are cold anomalies in the western north tropical Pacific and the North Pacific basin poleward of 40N. There has been no much attention given to PDV2 (Fig. 1b) although a similar pattern is discussed in Deser and Blackmon (1995). Moreover, there are no particular efforts to reveal connections between the first two dominant PDV and decadal modulation of ENSO amplitude. In order to examine whether the variability of PDV1 and PDV2 is associated with low frequency modulation of ENSO amplitude, weplotted N34Var along with PC time series of PDV1, PDV2 and the time series of NINO3.4 SST index. The decadal variations are readily apparent in both time series of the PCs; however, the variability of

PDV2 seems to have relatively longer timescales with phase alternating from the mid-1920s and the early-1970s.We first analyze whether the variability of PDV1 is associated with ENSO decadal modulation.

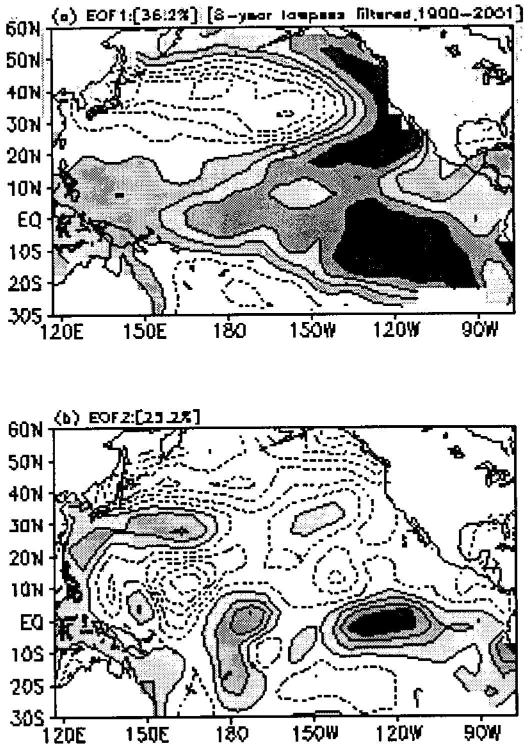
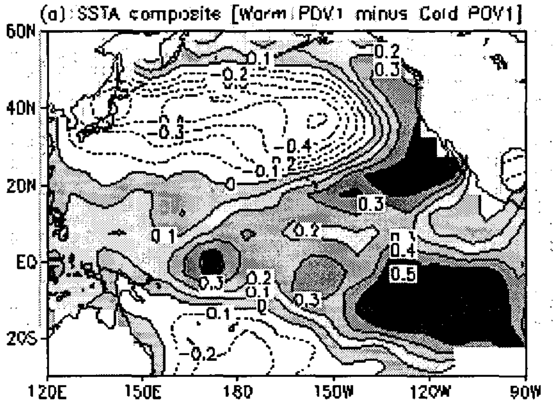


Figure 1 The first (a) and the second (b) EOF mode for the 8-yearrunning mean SSTA for the period 1900-2001. The first (second) EOF mode explains 36.2% (25.2%) of the filtered variance. Shading indicates positive value. Contour interval is 0.02. Unit is nondimensional.

There are periods when the PCs of PDV1 are in phase with N34Var and periods when the PCs are out of phase with N34Var. This simply suggests that there is little or no relationship between PDV1 and ENSO decadal modulation. To further examine the potential relationship between PDV1 and ENSO decadal modulation, we computed composites based on the PC time series of PDV1. Warm (cold) SST states of PDV1 are based on periods when the PC time series of PDV1 are above (below) zero. Figure 2a shows the composite SSTA by subtracting periods of cold state of PDV1 from periods of warm state of PDV1. The spatial pattern in the Pacific basin resembles PDV1; however, there is no detectable impact on ENSO amplitude. Figure 2b shows the difference in the SSTA standard deviation calculated separately for the warm and the cold states. This indicates that the PDV1(the PDO or the decadal ENSO-like variability), has no relationship with low frequency changes in ENSO amplitude. In order to confirm above result we take the reverse approach by using the N34Var to isolate the mean state related to ENSO decadal modulation. We compute the simultaneous linear regression coefficients between N34Var and Pacific SSTAs. The spatial structure of the Pacific mean state associated with ENSO decadal modulation is different from PDV1. The Pacific mean state associated with high ENSO amplitude is significantly correlated to cold states in the central and eastern North Pacific poleward of 40N and the western north tropical Pacific. There are limited statistically significant warm regions extending from the South Pacific to the central tropical Pacific. To clarify the Pacific mean state associated with ENSO decadal modulation, we performed a composite analysis. The high ENSO amplitude is based on periods when the ENSO amplitude index N34Var exceeds 0.62C. Similarly, the low ENSO amplitude is based on periods when the same time series is below 0.50C. The spatial structure of the Pacific mean SSTA is similar with the regressed pattern. The pattern correlation between the regressed SSTAs and composite SSTAs is 0.93. Warm SSTAs are trapped in the eastern and central tropical Pacific, and show an elongated structure from the South Pacific to the North central subtropics. Cold SSTAs are dominant from the North Pacific basin poleward of 40N to the western north tropical Pacific. Maximum differences in the SSTA standard deviation are located in the eastern Pacific along the equator and are on the order of 0.2~0.3C. Based on this brief analysis we conclude: (i) the dominant PDV, (here, PDV1) is not related to ENSO decadal modulation and is not a residual associated with periods of either more or less active ENSO and (ii) there are low frequency changes in the Pacific mean state that are connected to low frequency modulation of ENSO amplitude.


(a) SSTA composite [Warm PDV1 minus Cold PDV1]

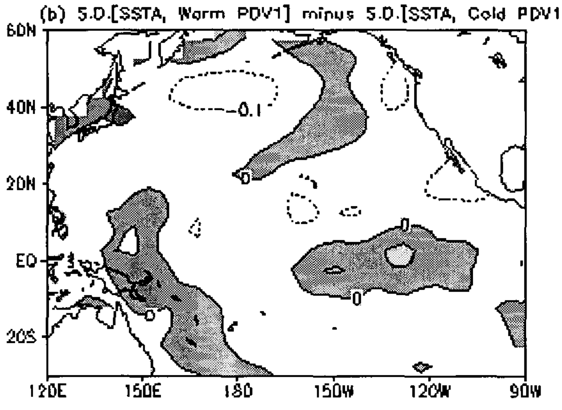

(b) S.D.[SSTA, Warm PDV1] minus S.D.[SSTA, Cold PDV1]

Figure 2 The difference of anomalous mean SSTAs between periods of warm PDV1 and and periods of cold PDV1 (a). Shading is for positive and contour interval is 0.1C. (b) is the difference of standard deviation for SSTA between the two periods. Contour interval is 0.1C.

3. Concluding Remarks

Our results focus on the relationship betweenthe Pacific mean SST and ENSO amplitude modulation. However, the analysis of SST only is not necessarily a sufficient indication of changes in the Pacific mean state that are important for ENSO. For example, changes in thermocline depth ofthe equatorial Pacific could be varying in a way that could produce ENSO amplitude modulation and such subsurface characteristics may not be evident in SST.

4. Reference

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5. Acknowledgement

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