Updated Assessments of the 1998/99 Climate Change over the North Pacific

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ABSTRACT

The anomalous climate conditions in the atmosphere and ocean over the North Pacific starting in 1998/99 are revisited using the updated data in the last five decade. The anomalous sea-surface temperatures and atmospheric circulations returned to the normal condition in the middle of the 2002. The sea-level displacement anomalies propagated as Rossby waves from the central North Pacific to Japan. It is suggested that the large part of the 1998/99 climate change can be understood as the quasi-decadal fluctuation of the East Pacific pattern and oceanic responses to it, and hence may be qualitatively different from the major climatic regime shifts in the 20th century.

Keywords: Decadal climate change, Climatic regime shifts, Air-sea interaction

INTRODUCTION

The possibility of the occurrence of the 1998/99 climatic regime shift has attracted rapidly growing attention from climate and marine ecosystem researchers. Substantial changes in climate were reported by [1–3]. Sea-surface temperatures (SSTs) over the central to western North Pacific were suddenly warmed, whereas SSTs along North America cooled. Furthermore, Ref. 4 recently reported the dramatic ecosystem changes in the coastal region in the eastern North Pacific, characterized by the decrease of sardine and increase of anchovy. These changes were opposite to the widely-known climatic regime shift over the North Pacific in the 1970s. The papers that studied the 1998/99 climatic change [1–4] emphasized importance of continuous monitoring of key parameters that showed substantial changes in the 1998/99. Therefore, the purpose of the present paper is to document updated conditions of the North Pacific in association with the 1998/99 change.

DATA

The gridded SSTs and sea-level displacements (SLDs) are analyzed. The SSTs are provided from the UK Meteorological Office as Hadley Center Sea Ice coverage and Sea Surface Temperature data (HadISST) ver. 1, and are produced on a monthly 1° × 1° grid from 1871 to November 2003. The SSTs incorporate ship and satellite observations, estimations from sea-ice concentrations, and interpolations based on Empirical Orthogonal Functions (EOFs) [5].

The satellite altimetry data gridded on 1° × 1° resolution are obtained from University of Texas (ftp.csr.utexas.edu). The Topex/Poseidon altimetry data are available during the period from Jan 1993 to August 2002, and Jason-1 altimeter data from February 2002 to July 2003. We modified the Jason-1 data so that the average of the Jason-1 data for the overlap period from February 2002 to August 2002 become the same as the average of the Topex/Poseidon data.

We also analyzed the East Pacific pattern index, provided by Climate Prediction Center (http://www.

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cpc.cep.noaa.gov/data/teledoc/telecontents.html). The East Pacific pattern is found to be strongly related to the 1998/99 change [1].

RESULTS

Dramatic changes of the SSTs in the three regions shown in Fig. 1 were already reported using the data until the beginning of 2002 [2]. SSTs in the Kuroshio-Oyashio extension region as well as the central North Pacific exhibited abrupt warming. On the other hand, SSTs in the eastern North Pacific sharply lowered. The updated time series on SST is shown in Fig. 2. SSTs in all these three regions returned to the condition before 1998/99 in the middle of 2002 (Fig. 2). Thus, the anomalous condition starting from 1998/99 continued four years, and at least temporally has terminated. The atmospheric circulation changes in the three major regime shifts of the 20th century, i.e., the regime shifts in the 1920s, 1940s and 1970s, are characterized by the strengthening and weakening of the Aleutian low [2], but the 1998/99 change is associated with the East Pacific (EP) pattern [1]. This may be consistent with

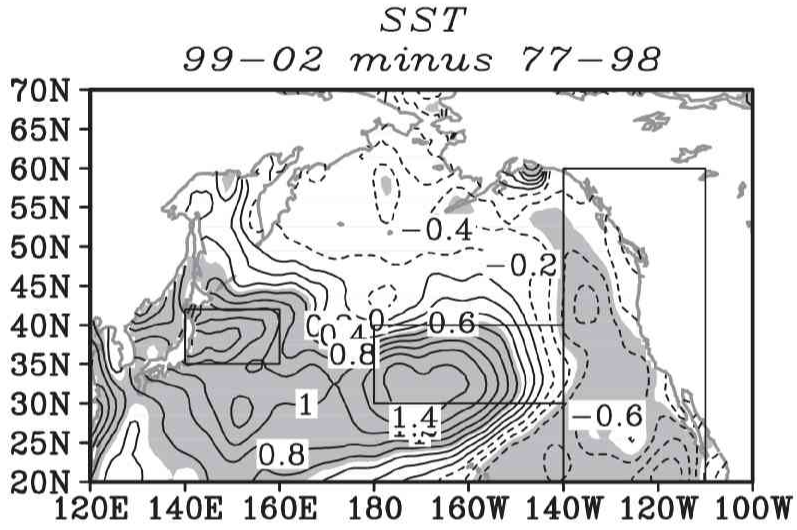

Fig. 1 Difference in Sea-Surface Temperatures (SSTs) between 1999–2002 and 1977–1998. The contour interval is 0.2°C, and the absolute value of the difference larger than 0.5°C is shaded. The SST time series averaged over the three rectangles are shown in Fig. 2. (Minobe 2002)

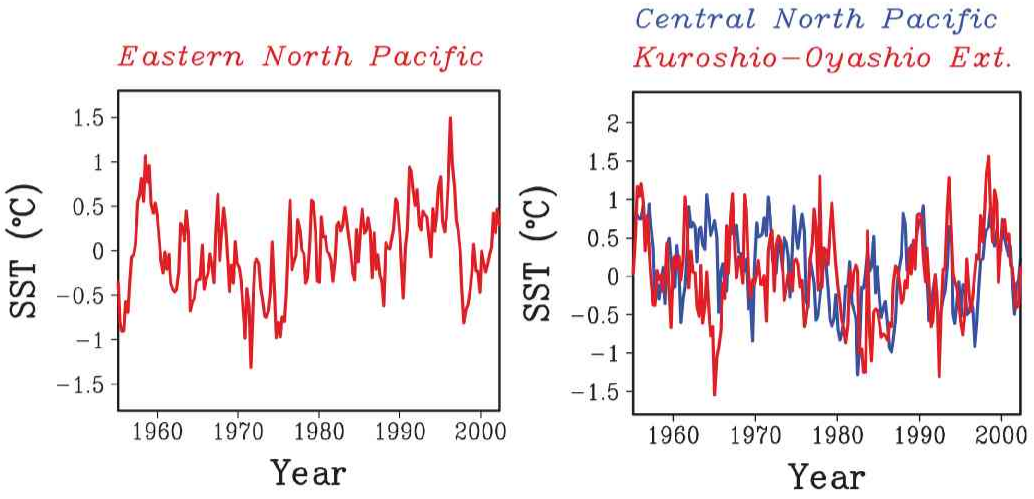

Fig. 2 Time series of Sea-Surface Temperatures (SSTs) until November 2003 averaged over the three regions shown in Fig. 1. The left panel indicates eastern North Pacific. In the right panel, the red and blue lines indicate Kuroshio-Oyashio extension region and the central North Pacific, respectively.

the interpretation that the 1998/99 SST changes may be related with the second EOF mode, but the 1970s shift is related to the first mode [6]. Figure 3 shows that the time series of EP index in winter is dominated by decadal (12–13 year period) variability after the middle of the 1970s. In association with this decadal fluctuation, the positive polarity from 1999 to 2001 and the near zero value around 2003 can be understood. However, a spectral analysis does not detect any significant decadal peak, and hence the apparent 12–13-year oscillatory behavior may arise from stochastic processes.

Another notable change in the 1998/99 is the fact that the SLD exhibited a tongue-like rise (Fig. 4). Figure 5 shows that the eastern end of the tongue, which is formed in 1999, propagated westward, and reached the Japanese coast in 2002. Even in the early 2003, the anomaly propagated from the central North Pacific was still observed over 30°–35°N, 140°–170°E. This may be a lagged response to the changes of the East Pacific pattern via oceanic Rossby waves.

CONCLUSIONS

The SST anomalies of 1998/99 change, after four-year persistence, returned to normal conditions in the middle of 2002. This is consistent with the decadal variability of the East Pacific pattern. The SLD rise formed in the central North Pacific propagated toward the west and took four-five years (1999 to 2003) to cross the half of the Pacific basin. This

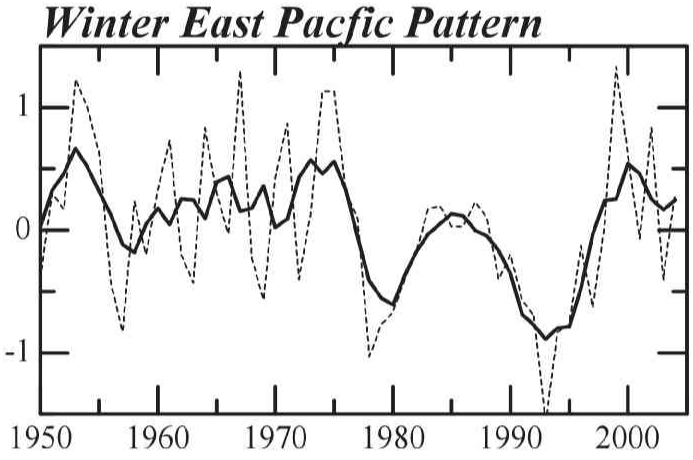

Fig. 3 Index of East Pacific pattern in the winter season. Dashed line indicates the raw data, and solid line indicates the data smoothed by a 5-yr running mean.

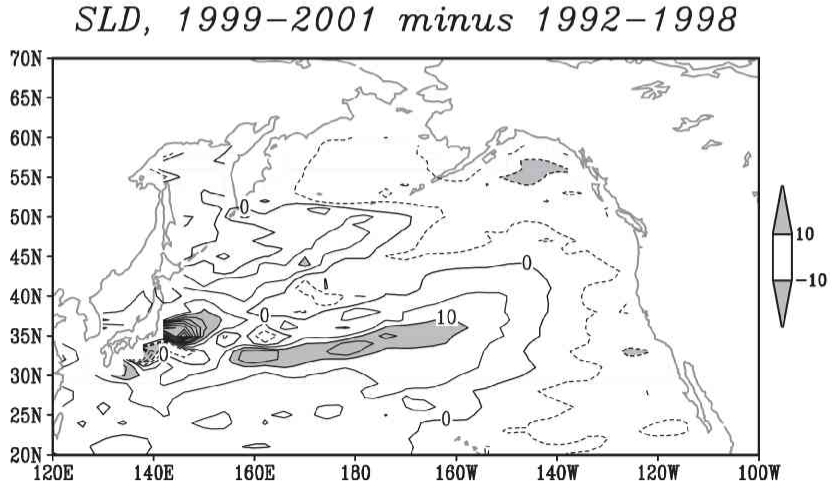

Fig. 4 Difference in sea-level displacements (SLDs) between 1999–2001 and 1992–1998. Contour interval is 5 cm, and shading indicates that the SLD is larger than 10 cm. (Minobe 2002).

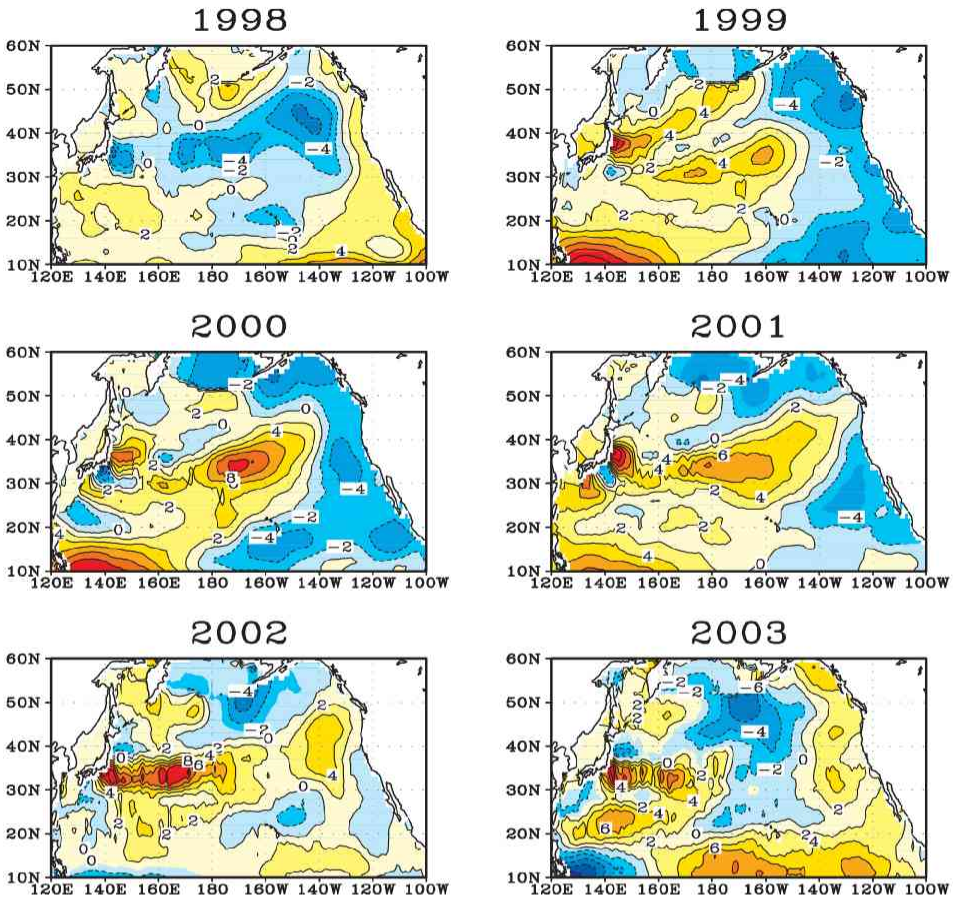

Fig. 5 Yearly averaged Sea-Level Displacments (SLDs) until July 2003, observed by Topex/Poseidon and Jason-1.

may be a lagged response of the ocean to the atmospheric forcing, represented by the East Pacific pattern. These results suggest that the large part of the 1998/99 change can be understood as the quasi-decadal fluctuation of the East Pacific pattern and oceanic responses to it, and hence may be qualitatively different from the major climatic regime shifts in the 20th century.

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