The Climate Regime Shift in Pacific Basin in Mid-Late 1990s: Mechanisms and Impacts

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Climate Regime Shift in late 1970s

1976-77 shift in both the eastern and central North Pacific Ocean (e.g., Miller et al. 1994)

Westward of the Western Pacific Subtropical High since the Late 1970s (Zhou et al., 2008)

Interdecadal variations of meridional winds in the South China Sea since late 1970s (Li et al., 2010)
Change in 1990s

Decadal change in the relationship between WNP summer monsoon and eastern Asian monsoon in middle 1990s (Kwon et al., 2005)

Interdecadal change of the South China Sea summer monsoon onset
A significant advance in the onset dates of the South China Sea summer monsoon is detected around 1993/1994 (Kajikawa and Wang, 2011)

A climate regime shift in northeast Pacific ecosystems (e.g., California current) around 1998 (Peterson and Schwing 2003)
For the interdecadal timescale, it is necessary to detect the regime shift signal in the global or at least basin scale.

Purpose:
In this study, a new CRS in the Pacific basin was identified around 1996/1997.
Method

Low frequency 10 years filter → EOF SVD → RSI (regime sift index)

A sequential algorithm for testing climate regime shifts

Rodionov (2004)
Basin-scale climate regime shift in Pacific around 1996-1997
SSTa EOF & regime shift index (RSI)

the PC1 shows a significant CRS around 1976/1977
the PC2 shows a significant CRS around 1996/1997
SVD of SSTa and 850hPa streamfunction

SVD1

(a) SST_hetlift_SVD 1 annual 64.9%

(b) StreamFunction_hetlift_SVD 1 annual 64.9%

SVD2

(d) SST_hetlift_SVD 2 annual 27.3%

(e) StreamFunction_hetlift_SVD 2 annual 27.3%

(c) SST_SF_SVD 1 cr=0.9 1976/77

(f) SST_SF_SVD 2 cr=0.93 1996/1997
A global scale CRS in late 1990s

Pacific

Pacific+Atlantic

Pacific+Atlantic+IO
non-detrended SVD2 (31%)

(b)  

StreamFunction_homlift_SVD 2 annual 30.6%

H L

(c)  

SST_SF_SVD2 30.6%

SF SST

CRS in 1996-1997

SVD2 (24%)

(d)  

SST_homlift_SVD2 annual 24.3%

(e)  

StreamFunction_homlift_SVD 2 annual 24.3%

H

(f)  

SST_SF_SVD2 24.3%

SF SST

CRS in 1996-1997
CRS of Pacific Oscillation

Adapted from https://climatebysurly.com/2014/09/18/the-record-of-the-ipo
Low-frequency SST evolution during the transition period of CRS in 1996/1997
temporal evolution during the CRS transition period
Physical processes
Hovmueller digram
lat: 5S-5N

(a) tendency(shaded)
temperature(contour)

(e) zonal wind stress (shading)
sea surface height

mixed layer heat budget

\[ \frac{\partial T'}{\partial t} = -(V' \cdot \nabla T + \bar{V} \cdot \nabla T' + V' \cdot \nabla T') \]

Ocean dynamic

\[ + \frac{1}{\rho C_p H} (Q_{SW} + Q_{LW} + Q_{LH} + Q_{SH}) \]

Surface flux

\[ + R \]
130~150E
(mixed layer depth: 46m)

155 ~ 185E
(mixed layer depth: 112m)
Schematic diagram to illustrate the physical processes of the CRS

ID1: 1986-1996

ID2: 1997-2007
Impacts:

Tc-Activity

Sever rainfall in mei-yu season

Aleutian low
tropical cyclone over different Pacific basin

(a) western North Pacific (WNP), (26.3)

(b) western South Pacific (WSP), (8.7)

(c) eastern North Pacific (15.3)
Change of TCs genesis and track density

IP1 (1986-1997) tc genesis freq

IP2 (1998-2009) tc genesis freq

IP2 - IP1, tc genesis freq

IP1 (1986-1997), tc track freq

IP2 (1998-2009), tc track freq

IP2 - IP1, tc track freq & steering flow
Relationship between GPI and SSTa PC2
CRS and Precipitation

(a) 1979-2007 Prec May
(b) PC1/RSI May
(c) 1979-2007 Prec June
(d) PC1/RSI June
Rainy day anomaly

(a) >0.1mm

(b) >50mm (大雨)

(c) >130mm (豪雨)
Aleutian low index
Conclusions

- An basin-scale CRS, which was characterized a CP-type La Nina mean state change, was identified in the Pacific during mid-late 1990s.
- The CRS initiated in the equatorial western Pacific and then evolves westward to CP and extra-tropics.
- No evidence shows that the CRS was resulted from the global warming, even though the warming trend may enhance the magnitude approximately 20%. (CP)
- A mixed layer heat budget analysis suggests that the physical processes that trigger the CRS differ in the EWP (net surface shortwave radiation) and ECP (oceanic zonal and vertical temperature advections).
- Significant impacts of CRS on the TC-activity in the Pacific, precipitation and Aleutian low was identified.
CRS and South China Sea Summer Monsoon Index

**P1: 1979 ~ 1993**
**P2: 1994 ~ 2006**

(Onset time 5/31)
(Onset time 5/15)

### SCSSM index

Change in 1994

### Precipitation & Vorticity (10^6)

- EQ: Equator
- 10N: 10° North
- 20N: 20° North
- 30N: 30° North
- 40N: 40° North

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15