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Impacts of the Two Types of El Nino on Summer Precipitation and Their Corresponding Mechanisms in East Asia

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Abstract: *Using the synthetic analysis method, this paper analyzes the differences and their corresponding mechanisms of summer precipitation in East Asia in EP and CP years, respectively. The results show that different types of* El *Nino do play a significant role in precipitation by regulating the different atmospheric circulations. The large amount of precipitation in EP year is more northward than CP years. Correspondingly, there is a cyclone in Northeast Asia in EP years with subtropical high anomalies southward, making the convergence of moisture with the southerly wind anomalies. With good vertical movement conditions, these atmospheric circulations provide a good atmospheric circulation background for the precipitation.*

Keywords: *El Nino; Summer Precipitation; Physical Mechanisms; East Asia*

1. Introduction

El Nino-Southern Oscillation (ENSO) is a significant factor affecting China's disasters such as drought and flood in summer[1], low-temperature rain and snow in winter[2]. It is the strongest inter-annual change signal in the tropical Pacific Air-Sea coupling system. The variability of precipitation fluctuates greatly during the El Nino event, and the abrupt year of precipitation is consistent with the El Nino year. El Nino also has an influence on the typhoon's activity, the result shows that typhoon's activity decreased in El Nino years and increased in La Nina years[3-4]. Some studies also found that ENSO also has an important impact on the East Asian winter monsoon[5]

In 2007, Ashok et al. contrive the "El Nino Modoki"[6] that the temperature of the Central Pacific Ocean is oddly high, while the temperatures of the eastern and western Pacific Ocean are oddly low. From then, it was named as Central Pacific El Nino[7]. Therefore, there are two types of El Nino: Eastern Pacific *El* Nino (EP) and Central Pacific *El* Nino (CP).

As shown above, previous studies focused only on the impact of the traditional El Nino on the East Asian monsoon without distinguishing the different effects on monsoon between the two different types of El Nino. However, due to the significant monsoon influence in East Asia, its summer precipitation is deeply related to the location of tropical SST anomaly. Therefore, the study of the different responses of East Asian summer precipitation to two types of El Nino events is conducive to deepening our understanding of the impact of El Nino on East Asian summer monsson and also has a certain reference value for the prediction of East Asian summer precipitation.

2. Data and method

The data used in this paper include: (1) the monthly average EP index (NEPI) and CP index (NCPI) from 1982 to 2021 provided by the China Meteorological Administration (CMA)[8]. Index definition: NINO3, NINO4 index is defined as NINO3 area (150 ° W -90 ° W, 5 ° S-5 ° N), NINO 4 area (160 ° E-150 ° W, 5 ° S-5 ° N). NEPI and NCPI are the Nino indexes of the eastern and Central Pacific respectively, which are defined as NEPI=Nino3-$\alpha\times$Nino4, NCPI=Nino4-$\alpha\times$Nino3, when Nino3$\times$Nino4>0, α=0.4, otherwise, α=0. (2) the monthly average precipitation from January 1979 to December 2021 provided by the US atmospheric and Oceanic Administration (GPCP V2.3)[9]. (3) the monthly geopotential height, wind, vertical velocity and relative humidity from 1948 to 2021 provided by the US atmospheric and Oceanic Administration (NCEP-DOE Reanalysis 2)[9]. The period studied in this paper is from 1982 to 2020 and the range of area is (50°E -160°E,10°N -70°N).

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Based on the winter NEPI and NCPI (monthly average: December, January, February), if a year's NEPI(NCPI) is larger than 0.5, then define the year as EP(CP) year. Especially, if it's winter NEPI and NCPI) are both larger than 0.5, choose the larger one. the EP and CP years are followed (Table 1 and Fig. 1). Then, use the method of composite analysis to investigate the precipitation, 500 hPa geopotential height, 850 hPa wind fields, relative humidity on 850hPa and vertical velocity on 850hPa of EP and CP years. Detailly, calculate the anomalies of these variables in each EP year or CP year (the next year summer of EP year or CP year) and then use a t-test to check the significance.

Table 1: CP and EP years

EP	1982/83,1986/87,1991/92,1997/98,2009/10,2015/16
CP	1987/88,1990/91,1994/95,2002/03,2004/05,2009/10,2014/15,2015/16,2018/19,2019/20

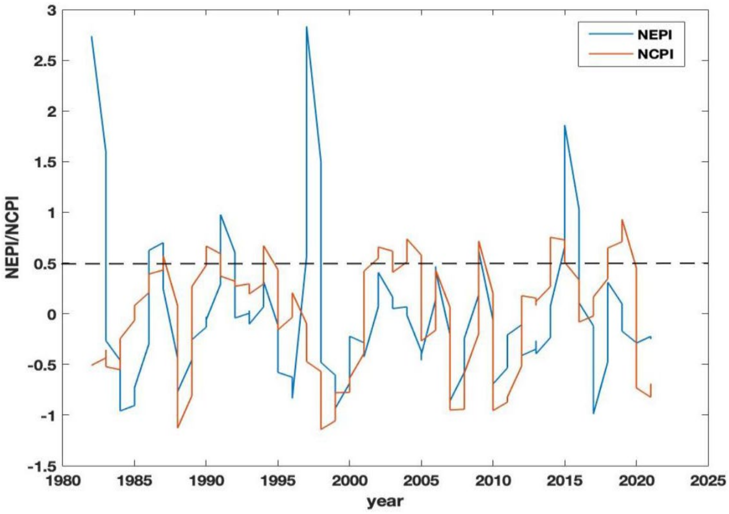

Figure 1: The time series of CP and EP indexes

3. Results

It can be found in Fig.2 that in EP years, in Inner Mongolia of China, the junction of the three northeastern provinces of China, the Central Plains of China and central Japan has more precipitation; while in Southeast Asia the precipitation is abnormally lower. In CP years, there is more precipitation around 40°N and in Inner Mongolia of China the precipitation is lower than average.

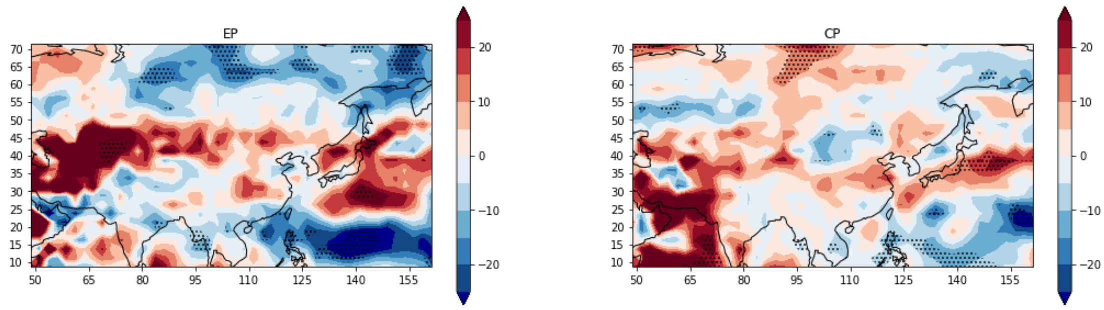

Figure 2: The composite maps of summer precipitation anomalies in EP and CP years, and the area above the 95% confidence level is dotted.

Therefore, what physical mechanisms drive the differences? As is shown in Fig.3, the subtropical high in CP years is northerly than that in EP years, which is conducive to the southerly wind to transport water vapor inland. Additionally, there is a cyclone in Northeast Asia in EP year (Fig.3 (a)), which is beneficial to the convergence of water vapor with the south wind. Consistent with the height field, the wind field has the same characteristics (Fig.3 (c), Fig3. (d)): the Southern wind in EP year is larger compared with that in CP year, providing more water vapor and making precipitation northwardly than that in CP year.

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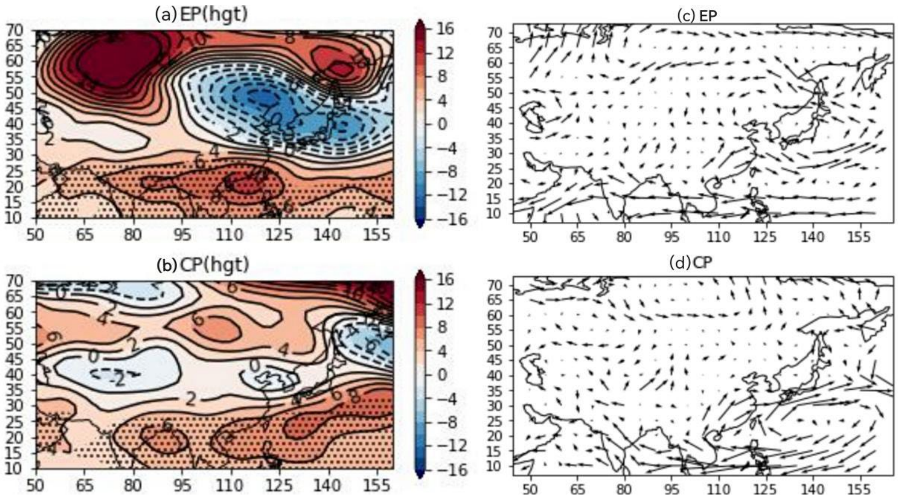

Figure 3: (a) (b) The composite maps of summer 500 hPa geopotential height in EP and CP years, and the area above the 95% confidence level is dotted. (c) (d) the composite 850 hPa wind vector field in EP and CP years.

As mentioned above, Fig.4 show that the wind vector field can provide the transportation of water vapor: the water vapor in the convergence area (45°N-55°N, 95°E-115°E in EP years) increases and the water vapor in the divergence area decreases (45°N-55°N, 95°E-115 °E in CP years).

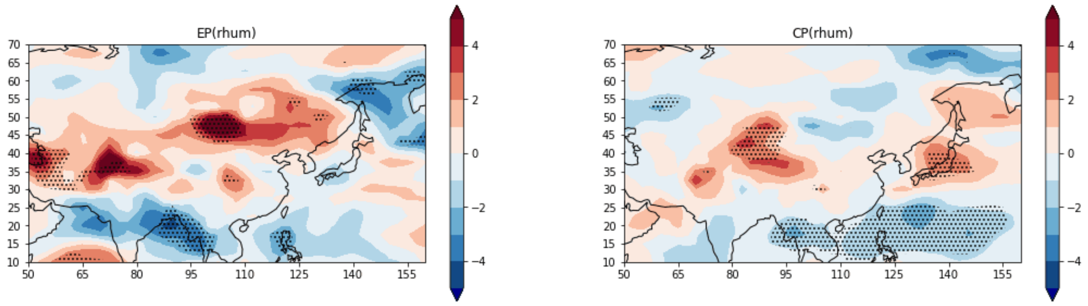

Figure 4: The composite maps of summer relative humidity in EP and CP years, and the area above the 95% confidence level is dotted.

According to the water vapor equation, the water vapor advection term plays an important role in precipitation. According to the wind field, geopotential height field and humidity field analyzed above: in EP years, the east wind over Japan transported the water vapor in the sea of Japan to Inner Mongolia through the three northeastern provinces, and the possibility of precipitation increased; In CP years, the wind field in Inner Mongolia is dominated by divergence. The wind field blows inland to the ocean, the water vapor advection is less and there is less precipitation.

The vertical velocity in Fig.5 also shows that the vertical motion plays an important role in the precipitation. The areas of upward motion in EP year is northward than that in CP years, which is good for the zone with high precipitation northwardly in EP year.

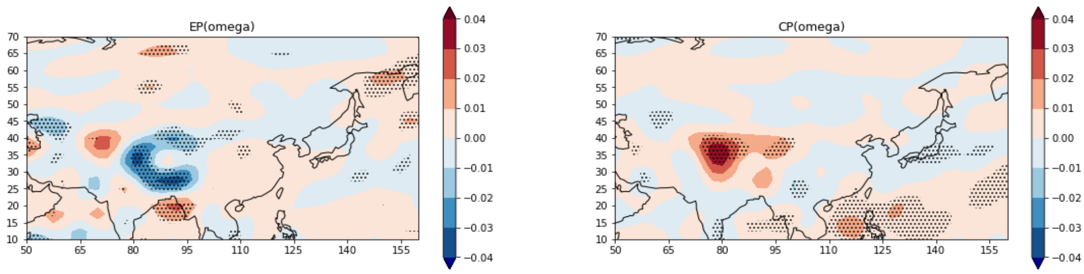

Figure 5: The composite maps of summer vertical velocity in EP and CP years, and the area above the 95% confidence level is dotted.

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4. Conclusion

Using the reanalysis dataset and the meteorological statistical methods, the different responses to the two types of El Nino on summer precipitation and their corresponding mechanisms are investigated.

The amount of precipitation in EP year is larger and more northward than that in CP year in all. Further analysis of their mechanisms, there is a cyclone in Northeast Asia in EP years with subtropical high anomalies southward, which is beneficial to the convergence of water vapor with the southerly wind, providing a good background for the precipitation. With good vertical movement conditions, it is conducive to the occurrence of precipitation.

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[9] Https://psl.noaa.gov/data/gridded/data.gpcp.html