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THE RELATIONSHIP BETWEEN SOUTH CHINA SEA SOUTHWEST MONSOON ANOMALIES AND IMPORTANT WEATHER IN GUANGDONG PROVINCE DURING THE RAINING SEASONS

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Abstract: The activity of South China Sea southwest monsoon (SCSSM) has direct impacts on the anomalies of important weather in Guangdong province during the raining seasons. So it is necessary to explore thoroughly the activity pattern of SCSSM and its relationship with important weather anomalies in the province. In this paper, the methods of composite analysis and correlation statistics are used to study the relationship between the onset date and intensity of SCSSM and the important weather, such as precipitation trends in Guangdong province during the annually first and second raining seasons, the timing of the annually first and last typhoon and the number of typhoons landing in Guangdong province. The results show that the rainfall is less than normal during the first raining season, but more than normal during the second one and there are more tropical cyclones landing in Guangdong province in the years of early SCSSM onset. The rainfall is more than normal during the second raining season and there are more tropical cyclones landing in Guangdong province in the years of strong SCSSM. The relationship between the SST of April - June, July - September and previous winter (December - February) and 500 hPa geopotential height and the onset date and intensity of SCSSM is analyzed. Some mechanisms between the onset dates and intensity of SCSSM and the important weather anomalies in Guangdong province are preliminarily explored. The results can be used for reference in short-term climate forecast.

Key words: southwest monsoon; raining season; monsoon onset; monsoon intensity

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1 INTRODUCTION

Being an important member of the East Asian monsoon system, the SCSSM influences large-scale and global weather and climate by its onset time and intensity [1 -5]. As early as the 1950s, summertime droughts and floods were found to be related with persistent anomalies of the general circulation. In 1934, Lan was the first to investigate into the links between the monsoon over the basin of the lower reach of the Yangtze River and the precipitation [6]. In 1962, a study of the causes for monsoon's advancement and retreat in East Asia and shifts of the rain belt gave a definite picture of the dependence of rainfall in various parts of China upon the intensity and onset time of the summer monsoon [7]. The relationships between persistent phenomena of summertime droughts and floods over the Yangtze and Huanhe Rivers basins were studied by Tao et al.[8]. Responses of precipitation in different parts of China are different to the summer monsoon, as indicated in a summary of the links between rains and monsoons [9, 10]. The relationships were sought between the anomalies of East Asia monsoonal circulation and the drought and flood weather in Yangtze and Huaihe Rivers basins and precipitation of the Yangtze River basin [11 - 13]. The association was also studied between the summer monsoon in East Asia and the large-scale anomalies of weather and climate in China [14]. The variability of summer monsoon in China and the droughts and floods during the Mei-yu (sustained rain) season were investigated for the links between them [15]. The Southwest Monsoon in the South China Sea was

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studied for its association with summertime precipitation in Guangdong province by Liang et al.[16] and Wu et al.[17]. Due to its importance, the SCSSM's relationships with major weather events during the annually first and second raining seasons, especially with typhoons and governing mechanisms, have been well addressed by meteorologists. Using the methods of composite analysis and correlation statistics, this study deals with the possible correlation between the onset timing and intensity of SCSSW and the precipitation trends of raining seasons and activities of tropical cyclones and associated generating mechanisms, and comes up with some suggestions on the effects of SCSSW on the mechanisms for governing major weather events in Guangdong, which are expected to have positive roles in the improvement of the forecast of droughts, floods and typhoons.

2 DEFINITION OF THE ONSET DATE AND INTENSITY FOR SCSSW

Large amount of work has been done on the summer monsoon in East Asia [18]. Owing to its complicated nature and varied understanding with the focus on wind or rain, however, as many as a few dozens of methods have been proposed for defining the index of the East Asian summer monsoon [19 -24]. For the index and onset date of the SCSSW, most of the researchers tend to determine them using the wind field, precipitation, OLR and subtropical high. At a workshop on the prediction of South China Sea monsoons held at Guangdong Meteorological Bureau in November 1997 by the National Climate Center, the following suggestion was put forward for the definition of the SCSSW: It is thought to begin if the pattern of East Asian circulation undergoes abrupt changes in association with the appearance of large-scale and persistent southwest wind for 5 days or more at the 850 hPa level over the South China Sea and adjacent areas, southwesterly flow originating from a diverted equatorial westerly of a relatively high intensity ($V_{max} \geq 10$ m/s or 5-day running mean wind speed ≥ 5 m/s) and intense convection over the South China Sea resulting from the eastward shift of the bulk of the subtropical high. Being one of the standards for judging the intensity of monsoon, the index is also a must in the research on its interannual variability. It is therefore an important issue of monsoon research across the world to define indexes for monsoons. Due to its geological location in the monsoon region of East Asia, the East Asian monsoon index has been well studied for extended periods of time, resulting in various definitions. Undoubtedly, large discrepancies exist between different indexes due to various focuses [25]. In view of the fact that the computations in Wu et al.[17, 26] have taken tropical characteristics into account with more accessible data, which makes them more applicable in routine forecast, their equations for onset dates and intensity will be used to determine those for each of the years studied (as shown in Table 1 and Table 2). The SCSSW is said to have an early onset if it starts before or in the second pentad of May, a late onset if it starts after or in the sixth pentad of May and a normal onset if it starts between the third and fifth pentads of May. The SCSSW is classified as strong with the standard deviation of the intensity $\sigma \geq 0.6$, weak with $\sigma \leq -0.6$, and normal with $-0.6 < \sigma < 0.6$. They are the basis for the analysis and research in this work.

See the Chinese edition of the journal for more details.

Table 1 Time of SCSSW onset in each of the years from 1950 to 2004 Unit: Month.Pentad

decade	0	1	2	3	4	5	6	7	8	9
1950	5.6	5.1	5.5	5.1	5.6	5.2	5.4	5.5	5.5	5.6
1960	5.6	5.3	5.4	5.6	5.4	5.5	4.6	5.4	5.6	5.5
1970	5.2	5.3	5.3	6.1	5.5	5.6	5.3	5.4	5.4	5.3
1980	5.4	5.3	5.6	5.5	4.6	4.5	5.2	6.2	5.5	5.4
1990	5.4	6.2	5.4	5.5	5.2	5.3	5.2	5.4	5.5	4.5
2000	5.3	5.2	5.3	5.5	5.4					

3 CONCLUSIONS

Analysis has been done in this study of the relationships between the onset and intensity of SCSSW and the important weather in Guangdong and the mechanisms behind the monsoon generation. The following conclusions have been drawn.

(1) For the year of early SCSSW onset, the rainfall is mainly less than normal in the annually first raining season but more than normal in the annually second raining season.

(2) For the year of strong SCSSW, the annual rainfall for Guangdong by typhoons is mostly more than normal at a rate of 81% (13/16) and precipitation is mainly more than normal at a rate of 69% (11/16) during the annually second raining season. For the year of weak SCSSW, however, the annual landfall is mostly less than normal at a rate of 58% (11/19); it is less than normal at a rate of 74% (14/19) during the annually second raining season (July – September).

(3) For the year of early SCSSW onset, the first

typhoon of the year appears early by a frequency of 67% (8/12) and the last one is also early by a frequency of 58% (7/12). For the year of late SCSSW onset, the first typhoon of the year appears late by a frequency of 60% (6/10) and the last one by a frequency of 80% (8/10).

Table 2 Standard deviation σ for SWSSW in each of the years from 1948 to 2003

decade	0	1	2	3	4	5	6	7	8	9
1940									0.154	-1.089
1950	1.258	0.682	0.382	-0.167	–0.531	-0.830	-1.348	-0.315	-0.606	0.106
1960	0.740	1.354	0.208	0.433	–0.193	-0.222	-0.634	1.206	0.640	-0.680
1970	-0.732	-0.790	2.659	0.407	0.905	0.666	0.116	-0.133	0.230	0.002
1980	-1.622	0.758	0.550	-1.041	0.757	1.484	-0.671	-0.825	-1.307	-1.220
1990	0.051	0.160	-0.627	0.068	1.089	-0.992	-1.776	1.512	-1.637	0.838
2000	0.072	0.036	1.131	-0.666						

(4) For the year of early SCSSW onset, the bulk of the subtropical high is more eastward and southward located than usual in April – June and South China is dominated by the center of negative anomalies, resulting in the meeting of cold and warm air masses off the region. It is mainly responsible for anomalously less precipitation during the annually first raining season.

(5) For the year of strong SCSSW, negative anomalies dominate the coast of South China – Bashi Strait while the center of positive anomalies is over the Yellow Sea and Aleutian Islands, with negative anomalies over Lake Balkhash and Lake Baikal. It shows that the ITCZ (the monsoonal trough) over the coastal area of South China is anomalously strong, the west Pacific subtropical high is anomalously northward and the westerly flow is anomalously weak. It is favorable for more activity of tropical cyclones, which increases both typhoon landfalls on the province of Guangdong and precipitation of the annually second raining season.

(6) The sea surface temperature (SST) in the zones of NiñoW and westerly drift, Warm Pool and the region of 15°N – 35°N, 140°E – 150°W have large impacts on the onset time and intensity of the SCSSW.

(7) In the years of early (late) SCSSW onset, the SCSSW is relatively strong (weak).

(8) The correlation is calculated between the onset date of the SCSSW and the 500 hPa geopotential height and SST gridpoint fields from December to February and some areas have been isolated that have passed reliability tests. These correlation regions show that the above gridpoint and SST fields during precedent winters are synoptically clear in affecting important weather events in the province and helpful in determining the onset of the SCSSW and the trends of these weather events.

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