Article ID: 1006-8775(2006) 02-0041-04

SOUTHWEST MONSOON SURGE AND ITS WEATHER IMPACT

FANG-Xiang (方　翔) [1,3], ZHENG Xin-jiang (郑新江) [2, 3], ZHU Fu-kang (朱福康) [4], LI Yun (李　云) [3], LI Zeng-zhong (李曾中) [4]

(1. School of Physics, Peking University, Beijing 100871 China, 2. Guangzhou Institute of Tropical and Marine Meteorology, CMA, Guangzhou 510080 China; 3. National Satellite Meteorological Center, CMA, Beijing 100081 China, Beijing 100081 China; 4. Chinese Academy of Meteorological Sciences, Beijing 100081 China)

Abstract: The sustained rainfall process on May 13－22, 2004 was one of the pre-summer rainy periods in the south of China. It was related with the genesis and development of a SW monsoon surge over the Bay of Bengal. From the synoptic analysis it is found that the genesis and development of the SW monsoon surge may be divided approximately into the initial, developing and decaying stages. During the rainfall the Southern Hemisphere cross-equatorial flow over the Indian Ocean plays a triggering role.

Key words: yearly-first rainy period in South China; SW monsoon surge; cross-equatorial flow

CLC number: P426.6 **Document code:** A

1 INTRODUCTION

Locating in the area of East Asian monsoons, China is subject to both the East Asian monsoon and Indian Monsoon and thus experiences changeable weather and climate that are difficult to predict. After the onset, the monsoon does not stay constant in intensity. Known as the "monsoon surge", weather phenomena change substantially when there is significant increase of wind speed[1]. A monsoon surge can be classified into the NE monsoon surge and SW monsoon surge[2]. Systematic research into the former can be found[3] while work on the latter is limited to a few contributors[4-6], who depend on conventional meteorological data to study the onset of SW monsoon surge, low-latitude circulation and their relationships with precipitation in Guangdong. Little work has been done on the monsoon surge from the viewpoint of the Bay of Bengal, possibly due to the scarcity of marine observations. QuikSCAT, a polar orbiting satellite for collecting ocean wind data, which was launched in June 1999, solved the problem of marine data scarcity in considerable extent. Even with QuikSCAT data, however, which most suits the purpose of measuring winds between 10 m/s and 30 m/s, winds greater than 30 m/s are difficult to retrieve and those less than 3 m/s unreliable to use for poorer accuracy[7].

Sea surface wind field of QuikSCAT, water vapor cloud imagery, infrared cloud imagery and conventional data are used in this work to study the evolution of SW monsoon surge in the Bay of Bengal (such as the characteristics of precipitation, low-level wind field and cloud imagery) and its causation. In the middle of May 2004, a sustained rain occurred in the province of Guangdong. Did it have anything to do with the SW monsoon surge? If they are related to some degree, where did the SW monsoon surge occur? How did it evolve? And what synoptic system drove it? They are what will be discussed in the paper.

2 SW MONSOON SURGE

In the middle of May 2004, two processes of sustained rains in Guangdong were found to originate from the SW monsoon surge in the Bay of Bengal. Fig.1 gives the day-to-day distribution of rainfall in Guangzhou in the month, which will be used as the case representing the two rains. The SW monsoon surge has two main sources. One is going north on the western coast of India coming up from the Arabian Sea

Received date: 2005-08-04; **revised date:** 2007-01-18

Foundation item: Research Fund for National Basic Research "The Theory and Method to Monitor and Forecast Rainstorms Causing Floods in South China" (2004CB418305)

Biography: Fang Xiang (1972-), male, senior engineer, mainly undertaking the study on the application of satellite remote sensing.

E-mail: fangxiang@nsmc.cma.gov.cn

and the other from the Bay of Bengal[2]. It is known from the analysis of the QuikSCAT sea surface winds that the SW monsoon surge originates from the Bay of Bengal instead of the South China Sea. Its evolution can be divided into the initial, developing and decaying stages.

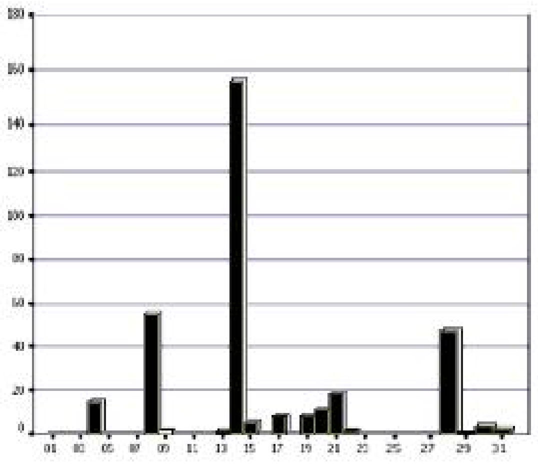

Fig.1 Distribution of day-to-day rainfall in May 2004 in Guangzhou. Unit: mm.

2.1 The initial stage

The southwesterly wind was not significant over the Bay of Bengal before May 10, 2004. A quasi-stationary westerly zone was prevailing near 12°N (Fig.2) with main cloud systems being active south of 15°N (figure omitted). On the imagery of water vapor (figure omitted), an area of fine sky appeared north of 15°N from the Bay of Bengal to the South China Sea, with upper-level moisture concentrating in the area south of 15°N. The two areas are clearly divided on the border and the Bay of Bengal is generally calm.

After May 10, the quasi-westerly zone was

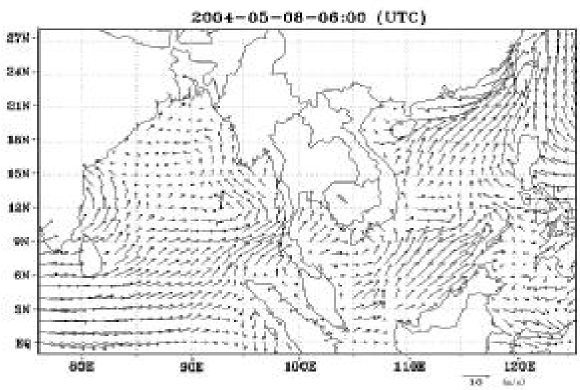

Fig.2 Sea surface wind field over the Bay of Bengal at 06:00 (UTC) May 8 2004.

disrupted over the Bay of Bengal so that the southwesterly advanced northward and dominated the whole bay by May 15 (Fig.3). In the meantime, the South China Sea was in the control of the easterly while the southwesterly did not enhance significantly. It is just the time when the sustained rain began in Guangdong.

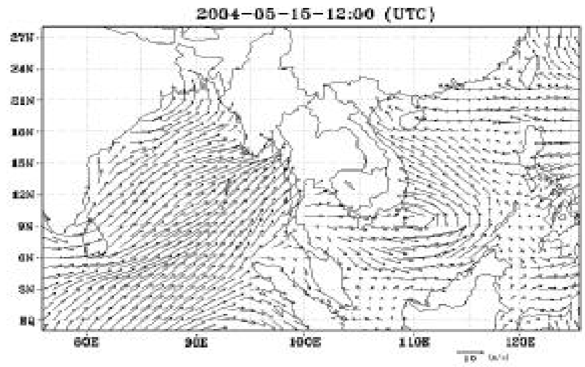

Fig.3 Sea surface wind field over the Bay of Bengal at 12:00 (UTC) May 15 2004.

2.2 The developing stage

With the northward advancement of the Bay of Bengal southwesterly, water vapor is transported along with it in roughly three separate processes. It is interesting to note that as water vapor travels northeast with the southwesterly, it makes a counterclockwise rotation at sea when it meets the coast of Indo-china Peninsula, which shows on the imagery as a SW-NE cloud system turning counterclockwise towards NW-SE to form a cloud cluster over the Bay of Bengal. As the land around the bay is moderate in the height above sea level, such counterclockwise directional turns of the cloud system cannot be contributed by the blocking effect of local topographies. It may be caused by inhomogeneous distribution of atmospheric energy over land and sea. In contrast to land, air over the ocean is both hot and humid so that energy accumulates at the lower levels of the atmosphere much more than that over land, which is a favorable condition for convective clouds to develop at sea. A new question then appears. Does water vapor from the southwesterly of the bay no longer travel over the Indo-china Peninsula and transport northward during the developing stage of the SW monsoon surge? It does not appear so according to the analysis. On the map of water vapor (figure omitted), an extensive dark area was present before May 10, a sign that it was mainly dry at the middle and upper levels. It is also known from the 850-hPa wind field for Bangkok in the Indo-china Peninsula (Tab.1) that the southeasterly was the prevailing wind at lower levels when there was not any channels for water vapor of the Southwest Monsoon.

Tab.1 Wind data at 850 hPa in Bangkok at 00:00 (UTC) May 1 – 20, 2004

Date	1	2	3	4	5	6	7
Vane							
Date	8	9	10	11	12	13	14
Vane							
Date	15	16	17	18	19	20	
Vane							

2.3 The decaying stage

The end of the sustained rain in Guangdong was coincidental to the east-moving and disappearance of the cyclonic cloud cluster that had developed intensely over the northern Bay of Bengal on May 17 – 18, 2004. The cloud cluster moved eastward and rapidly weakened but did not dissipate when it moved into land. Fig.4 gives its general track as it moved to the east, in which the day-to-day locations are determined with the geometrical center of the cluster. It did not dissipate until after it came near Guangzhou May 22nd when the sustained rain also came to an end in the Guangdong province.

From the above analysis of the generation and development of the SW monsoon surge in the Bay of Bengal in the middle of May 2004, it is known that it has distinctive stages of evolution and is associated with the sustained rainy weather in Guangdong. In addition, it is also noted that the cyclonic cloud cluster is reflected clearly in the sea-level wind field by QuikSCAT by showing a strong cyclonic circulation with the cyclogenesis in the northern Bay of Bengal (Fig.5). It is called the Bay of Bengal Low. In contrast, a low pressure covers the whole bay on the conventional upper-level weather map and no such cyclonic circulation is discerned (figure omitted).

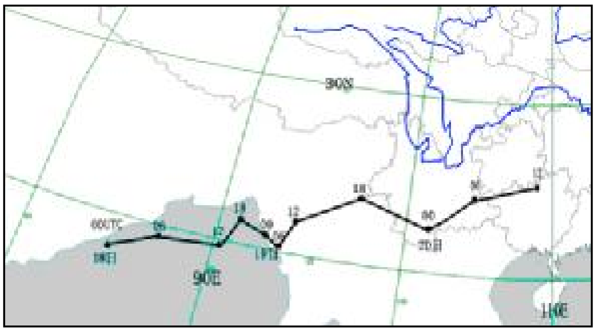

Fig.4 Eastward movement track of the cloud cluster on May 18 – 20, 2004.

3 CROSS-EQUATORIAL AIRFLOWS IN SOUTHERN HEMISPHERE

The analysis above mainly describes the generation and development of the SW monsoon surge in the Bay of Bengal. Where did it come from, then? In the area from the Indian Ocean to the west Pacific, low-level cross-equatorial airflows often prefer some parts of the world to others, called channels, due to inhomogeneously distributed pressure gradients and topographic factors. There is such a channel near 90°E in the bay[8], which is much less unstable than the Somali jet stream. According to the work by Li et al.[9], cross-equatorial airflows heading north during summer monsoon mainly occur in low levels near 850 hPa. In this work, the extremes of equatorial *V* component within the area from 80°E to 95°E are used to represent the intensity of the cross-equatorial airflows in the region of the Bay of Bengal.

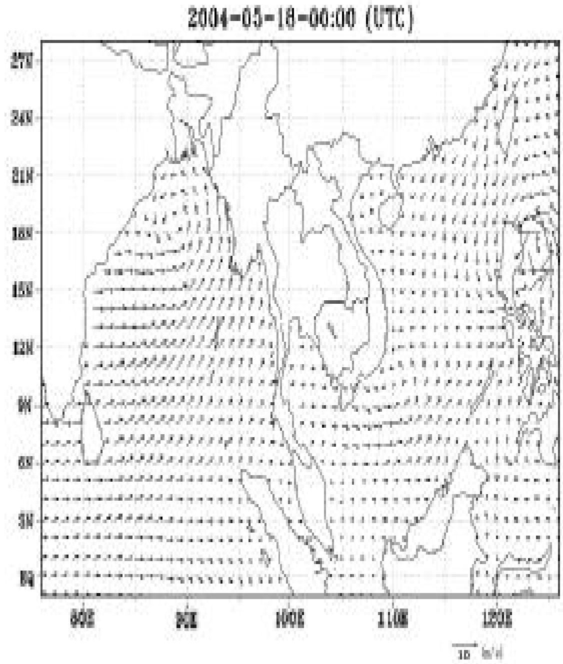

Fig.5 Sea surface wind field over the Bay of Bengal at 00:00 (UTC) May 18 2004.

Fig.6 gives the day-to-day evolution of the cross-equatorial airflows V_{max} at 850 hPa between 80°E and 95°E in May 2004. It can be preliminarily concluded from the figure that the SW monsoon surge is driven by cross-equatorial airflows from the Southern Hemisphere, which reaffirms our belief that the austral cross-equatorial airflows play a role in exciting the SW monsoon surge.

For analyses of other aspects, refer to the Chinese edition of the journal.

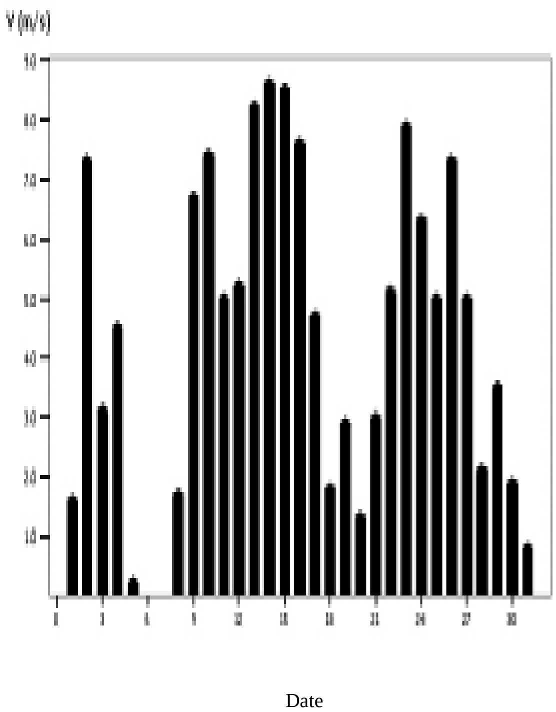

Fig.6 Day-to-day evolution of the cross-equatorial airflows V_{max} at 850 hPa between 80°E and 95°E in May 2004.

4 CONCLUSIONS

The yearly-first rainy season in southern China appears in early summer. The sustained rainy weather during May 13 – 22, 2004 in Guangdong province was a typical process in the season.

(1) The sustained rain was linked with the generation and development of the SW monsoon surge in the Bay of Bengal.

(2) The SW monsoon surge in the Bay of Bengal was made up of initial, developing and decaying stages.

(3) The monsoon surge was driven by cross-equatorial airflows from the Southern Hemisphere from 80°E to 95°E in the Indian Ocean.

Acknowledgements: Mr. LI Xiao-long took part in the relevant work during the study.

REFERENCES:

[1] Editorial Committee for Dictionary for Atmospheric Sciences. Dictionary for Atmospheric Sciences [M]. Beijing: Meteorological Press, 1994: 1-980.

[2] LIANG Bi-qi, WANG An-yu, LIANG Qin-ping, et al. Tropical Meteorology [M]. Guangzhou: Sun Yet-Sen University Press, 1990: 1-383.

[3] DING Yi-hui. A statistical study of winter monsoons in East Asia [J]. Journal of Tropical Meteorology, 1990, 6(2): 119-127.

[4] XUE Hui-xian, RONG Guang-xun. The relationship between the SW monsoon surge on 850 mb in the northwest part of south china sea and the heavy precipitation in Guangdong [J]. Journal of Tropical Meteorology, 1985, 1(3): 225-233.

[5] ZHONG Rong-gen. The changes in the circulation and atmospheric structure over low latitudes during the retreat of last southwest summer monsoon surge [J]. Journal of Tropical Meteorology, 1986, 2(3): 257-262.

[6] XIE Ju-lun. Analysis and forecasting for break-time of southwesterly monsoon surge in Nansha Islands [J]. Marine Science Bulletin, 2000, 19(1): 29-33.

[7] WU Xiao-jing, CHEN Yun-hao, ZHENG Xin-jiang, et al. Remote sensing of ocean wind fields with QuikSCAT/SeaWinds [J]. Journal of Natural Disasters, to be published.

[8] WEI You-xian, YANG Ya-zheng. On the relationships between the subtropical high and typhoons in China over the past 10 years [J]. Meteorological Science and Technology, 1982 (2): 1-9.

[9] LI Zeng-zhong, LOU Guang-ping. A study on the passages of cross-equatorial current during the southern monsoon [J]. Chinese Journal of Atmospheric Sciences, 1987, 11(4): 313-319.