Atmospheric and Climate Sciences, 2017, 7, 382-399
http://www.scirp.org/journal/acs
ISSN Online: 2160-0422
ISSN Print: 2160-0414

Analysis on the Process of a Convective Rainstorm of Stationary Front Triggered by Weak Cold Air

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How to cite this paper: Chen, J., Zhang, X.K., Li, J.Y. and Lin, Z.G. (2017) Analysis on the Process of a Convective Rainstorm of Stationary Front Triggered by Weak Cold Air. *Atmospheric and Climate Sciences*, **7**, 382-399.
http://dx.doi.org/10.4236/acs.2017.73029

Received: December 19, 2016
Accepted: July 24, 2017
Published: July 27, 2017

Abstract

Based on the conventional meteorological data and the NCEP/NCAR 1° × 1° reanalysis data and those related to mid-scale automatic station, satellite cloud picture and radar return, with the dynamic diagnosis analysis method, an analysis is made on the process of the convective rainstorm of quasi-stationary front triggered by the weak cold air on June 4-7, 2014, showing: 1) the process occurred in the event of convection of a stationary front triggered by the eastward moving south trough and the southward moving weak cold air from west under the background of circulation of two ridges and one trough at the Asian-European mid-high latitude and weakening and southeastward moving subtropical high; 2) a system configuration that contributes to convective rainstorms formed in the event of the convergence of low-level moisture, upper-level divergence and the continuous vertical ascending motion after the 200 hPa upper-level jet stream moved westwards from east and the 850 hPa southwest jet stream intensified; 3) after the intrusion by weak cold air of the meso-scale katallobaric area formed by the accumulated warm moist air of Guangxi before the intrusion, the warm moist air rose to trigger convection; convection cells developed and spread nearby the boundary between anallobaric area and katallobaric area, during which total 5 MCSs developed and each formed a rainstorm center at the part where the MCSs coincide; a meso-scale katallobaric area forms and develops 2 - 5 hours earlier than convection, so that it is also a warning of heavy rains.

Keywords

Weak Cold Air, Stationary Front, Convective Rainstorm, Guangxi

1. Introduction

As a main disastrous weather during the pre-rainy season (from April to June) in Guangxi, a rainstorm is closely associated with the south trough, shear line, southwest jet stream and front activities. Through studies on the occurrence, development and maintenance of rainstorms, there have been a large number of achievements for forecast application and reference (Gu, etc., 2012) [1] [2] [3] [4]. In combination with years of experience, Guangxi experts conclude that the indexes of conceptual model forecast (Huang, etc., 2012) [5] based on conventional meteorological data have played a significant role in the years of rainstorm forecast. However, in recent years, with the extensive application of midscale automatic station, satellite cloud picture and Doppler radar, there are some deficiencies in the application of the forecast indexes. In the process of a rainstorm caused for the reason that the weak cold air moves southwards from the east highland, there are rarely observation stations along the moving route through a highland and the large time-interval of conventional observation data, it is possible to ignore the measurement of the southwards moving weak cold air or fail to include it the conceptual model of frontal rainstorms, thus leading to rainstorm forecast failure. Therefore, to further improve the accuracy of rainstorm forecast, it is important to understand how to improve the level of analysis on weak cold air motions and discuss and supplement non-conventional observation data forecast index in combination with conventional and non-conventional observation data.

On June 4-7, 2014, a large-scale rainstorm hit Guangxi together with severe convection weather like thunder, lightning and gale, leading to heavy casualties and property loss. Through analyses, this occurred for the reason that weak cold air diffused southwards from the highland. As the warm-core cyclone developed on June 1-3 and the 997.5 hpa north-to-south closed contour extended northward to the west of Hetao, the cold air moves northwards on a weak basis. In addition, it is difficult to forecast the rainstorm considering the southern China is under the control of subtropical high, the south trough has a few amplitude, the shear line is located in the south of Yangtze River and it is easily to ignore the motion of air cold as the change in the pressure of the east highland to the observation stations in Guangxi is equivalent to the daily change.

In combination with the conventional meteorological data and the NCEP/NCAR 1˚ × 1˚ reanalysis data, midscale automatic station, satellite cloud picture and radar return, the paper makes a meteorological diagnosis and meso-scale analysis of the rainstorm and discusses the cause and the characteristics of the meso-scale convective system leading to the continuous short-term heavy rainfall, thus providing a basis for further understanding the triggering of convective storms by weak cold air from highlands and forming forecast experience for application and reference. By improving the level of weak cold air activity analysis, so as to further improve the accuracy of rainstorm forecast. This is of great significance for the prevention of a series of natural disasters caused by heavy rains, the protection of the people's personal safety and the reduction of the people's property.

2. Overview of Rainstorm Process

On June 4-7, 2014, under the common impact of the eastward moving 500 hPa south trough, stationary front and south-west warm-wet airflow, Guangxi was hit by a continuous large-scale rainstorm from north to south, with most areas hit by rainstorm and downpour, individual towns hit by extraordinary rainstorm and part towns hit by 8 - 9-level gale together with thunder and lightning. In this paper, conventional meteorological data from China Meteorological Data Network, combined with mesoscale automatic station monitoring data in Guangxi Province, for data analysis. Getting the distribution of rainfall in Guangxi Province. According to the rainfall from 8:00 a.m. of June 4 to 8:00 p.m. of June 7, there were 4 towns and villages where the rainfall exceeds 300 mm, including Pulu Village, Lipu County, Guilin (330 mm), Huangmian Village, Luzhai County, Liuzhou (328 mm), Zhaisha Town, Luzhai County, Liuzhou (328 mm) and Hualong Town, Lipu County, Guilin (308 mm); there were 80 villages and towns throughout 18 counties (districts) where the rainfall is between 50 - 100 mm; there were 300 villages and towns throughout 70 counties (districts) where the rainfall is between 100 - 200 mm; there were 541 villages and towns throughout 102 counties (districts) where the rainfall is between 50 - 100 mm (**Figure 1**). In accordance with the information provided by the Department of Civil Affairs of the municipality at 4:00 p.m. on June 8, 419,400 persons of 41 counties (districts) throughout 10 cities of Guangxi have been hit by the rainstorm since June 4, 2014, including 4 deaths. In addition, the rainstorm also resulted in the damage to 24,210 hectares of crops, 1218 rooms of 537 houses and the direct economic

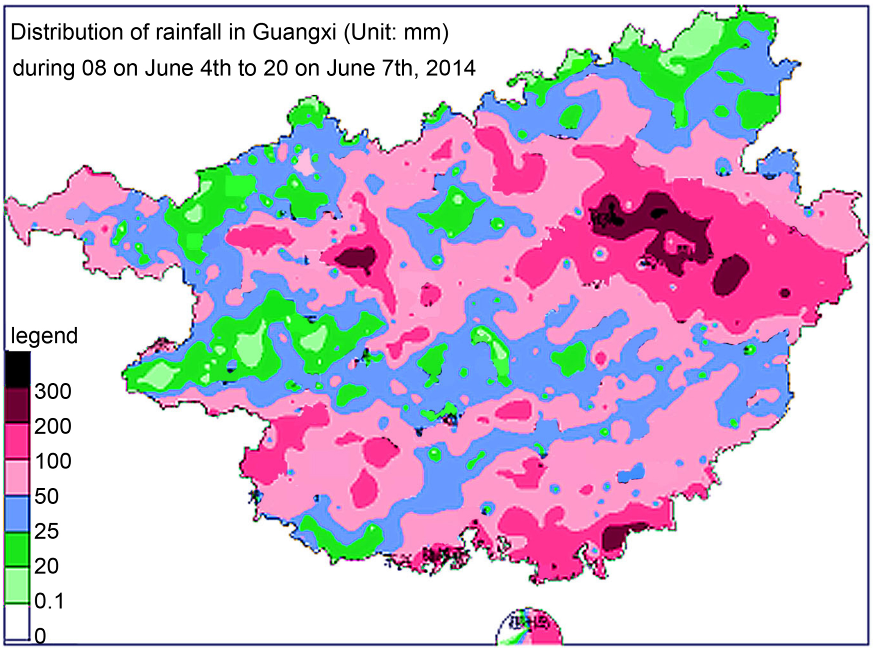


Figure 1. Distribution of rainfall in Guangxi during 08 on June 4th to 20 on June 7th, 2014.

loss of RMB 399 million.

3. Analysis of Weather Characteristics

On June 1-4, 2014, there were two ridges and one trough at the Asian-European mid-high latitude of 500 hpa, of which the two ridges are respectively located in the Eastern Europe and the zone from the Sea of Japan to Northeast China, and the low trough is located in the zone from the Ural Mountain to the Lake Toba (Left of Figure 2).

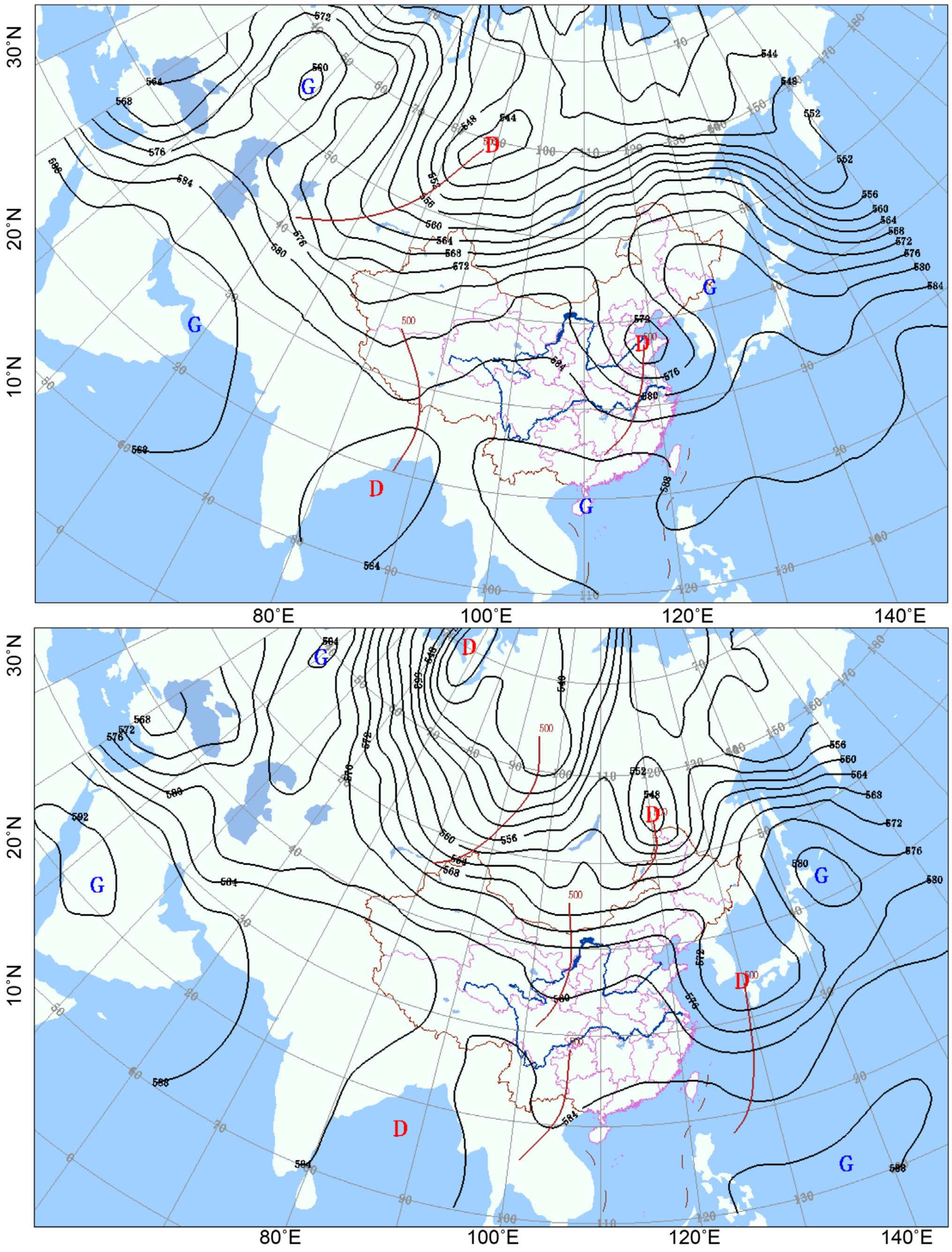


Figure 2. June 1, 2014 20 and at 20 on June 5th 500 hPa height field (left: June 1st 20 right: at 20 on June 5th).

The high-pressure ridge of the Eastern Europe gradually intensifies and the low trough slowly moves eastwards, making the high-pressure ridge of the northeast China slowly move eastwards either; furthermore, a cold eddy was reserved in the zones around the Bohai Bay and the Yellow Sea, so that the northward-moving air stream at the west leads southwards the weak cold air from the east of the northwest district to the east of the highland in the process of weakening the eastward movement to hit the areas including southwest and southern China; the subtropical high of the southern China gradually weakened and moved from south to east; the monsoon low of the Bay of Bengal continuously intensified; the south trough moved to Guangxi through Yunnan, Guizhou. On June 4-7, the 500 hpa subtropical high moved from south to the east of the Philippines, and the south trough moved into Guangxi with the amplitude of over 10 latitude distances (Right of **Figure 2**) corresponding to the period of the heavy rain in Guangxi.

On June 2-3, there was developing low pressure between 297 - 303 dgpm in the west of the Sichuan Basin under 700 hpa, which shows an obvious diurnal variation and that the west-southwest air flow from the Yunnan-Guizhou Plateau to southern China. On June 4, when the weakening cold eddy of the Yellow Sea moved eastwards, it turned to north wind from Hetao to the south of the Yangtze River and then to east to northeast wind, thus forming a shear line with the southwest airflow of southern China. On June 5, the northeaster at the north of the shear line moved to the west of 105˚E along the upper reaches of Yangtze River, and the regions of the Hexi Corridor are not less than 309 dgpm high, thus contributing to the heavy rain hitting southern China.

On June 2-3, the 850 hpa weak shear line was located in the mid-southern Guizhou; on June 4, the line slightly intensified and was located in the junction between the southern Guizhou and Guangxi; on June 5, the line intensified and entered the Northern Guangxi. The 144 dgpm line passed through Guangxi via the Indo-China Peninsula from the Bay of Bengal, turned left upon arrival at the southern Hunan and formed a cyclonic curve of large curvature in the north Guangxi; the east-to-northeast airstream in the north of the shear line extended from the south of the south of the Yangtze River to Guizhou, resulting in significantly intensifying convergence; the southwest jet in the south of the shear line formed and conveyed unstable energy and moisture upwards in Guangxi, thus contributing to a heavy rain and severe convection weather.

On June 1-2, the southwest warm-core cyclone developed and the 997.5 hpa south-to-north closed contour extended northward to the west of Hetao. On June 3-4, the weak cold air of the northwest regions moved southwards, while the cyclone in the north weakly moved northeastwards, and the cyclone in the south moved to Yunnan, leaving northeaster in the south of the Yangtze River and south wind in the southern China and thus forming a stationary front between the southern Guizhou and Guangxi. On June 5, the weak cold air diffusing southwards from the east of the northwest district and the eastern highland intensified the stationary front and made it enter the northern Guangxi. Upon commence of the heavy rain, the stationary front moved southwards in Guangxi and disappeared until June 7.

According to the analyses of the evolution process of the weather system above, no system configuration that contributes to a rainstorm formed before June 3. On June 4, when the western warm-core cyclone was divided into the north and south parts, a positive pressure variation occurred from the eastern highland to Yunnan and the 500 hpa south through moved eastwards, while the 700 hpa and 850 hpa shear lines moved southwards, thus forming a system configuration (frame) of the stationary front rainstorm and meeting the condition of rainstorm forecast. In such case, the intensity was still weak. On June 5, the southwesterly jet in the south of the shear line formed, making the coverage and intensity of the rainstorm increase. Therefore, the continuous rainstorm was uncertain in the early stage and sudden in the late stage and was also a surging rain caused by weak cold air.

Combined with previous research experience and rainstorm forecasting criteria, selecting the following factors as Guangxi static front rainstorm forecast indicators:

1) Surface stationary front, inverted trough;

2) 500 hPa high-altitude slot amplitude ≥ 8 latitude, groove line and 30˚N intersection between 95˚E - 115˚E;

3) 700 hPa shear line north of the northeast wind along the upper reaches of the Yangtze River to 105˚E west, 700 hPa Hexi Corridor area H ≥ 309;

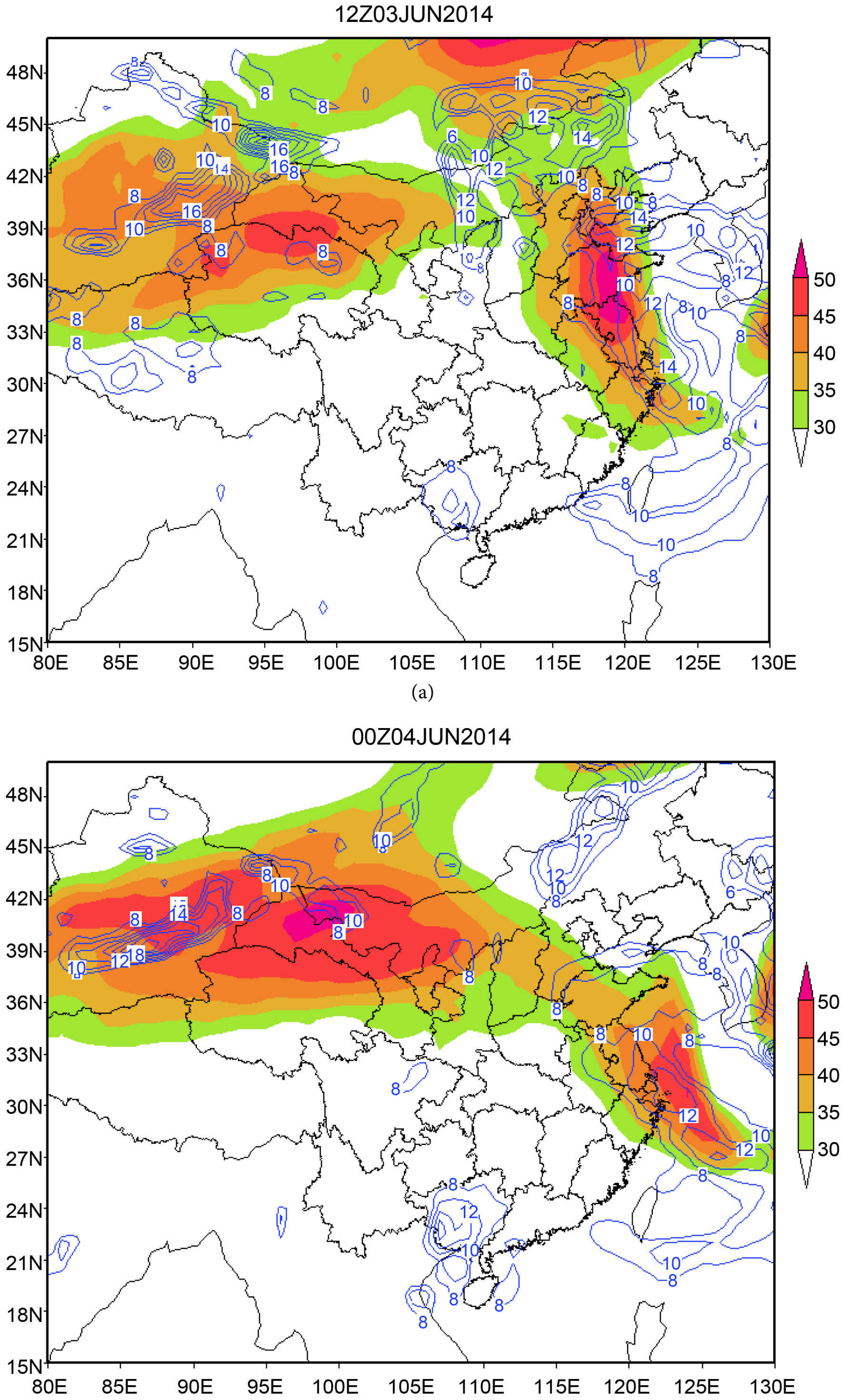
4) 850 hPa shear line north of the northeast wind range has more than 3 latitude, Nanning H ≤ 146;

5) Thickness of saturated layer. 850 to 200 hPa, T-Td ≤ 4˚C, Si ≤ 2˚C or (T850-T500) ≥ 22˚C.

4. Analysis of Physical Characteristics

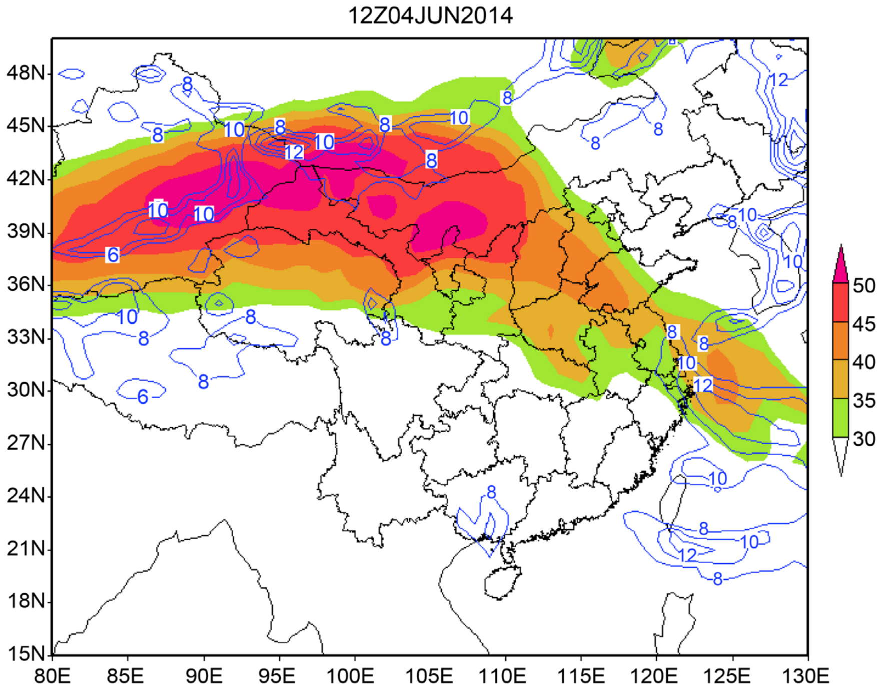
4.1. Dynamic Conditions

Studies and practices show that upper-level and low-level jets are the most important large-scale dynamic environmental factors that contribute to the occurrence and development of a rainstorm, especially the low-level jet considered an important mechanism that provides moisture and momentum for rainstorms at the mid-low latitude as the zone where momentum, heat and moisture are densely distributed (Ding, etc., 2013) [6] [7] [8]. Through comprehensive analyses of the 200 hPa upper-level jet and the 850 hPa wind on June 3-7, 2014, there was an upper-level jet nearby 40˚N on the 200 hPa upper-air map and Guangxi was located within the area of divergence at the right of the upper-level jet axis (**Figure 3**). During the period from 8:00 p.m. of June 3 to 8:00 p.m. of June 4, the jet axis turned to the east-west direction, after which the jet form, intensity and location maintained less change. Meanwhile, according to the profile map between the 850 hPa wind speed and wind field time (**Figure 4**), during the period, the south trough moved eastwards, so that the warm-wet air gradually moved nearby Guangxi, making the low-level jet gradually intensify and the southerly jet core of the largest wind speed of over 12 m/s arouse in the south central Guangxi from the nighttime of June 4 to June 5; the northern Guilin was located in the positive vorticity area at the left of the exit of the low-level jet, forming an upper-level and low-level jet coupling configuration with 200 hPa wind and thus gradually leading to a heavy rain. When the southwesterly flow intensified, the east airflow would also intensify. The two jets from the west and



(a)

(b)



(c)

Figure 3. June 3, 2014 20 (a) to 5 at 08 (b) 200 hPa high altitude jet and 850 hPa low-level jet superposition chart (m·s^{-1}).

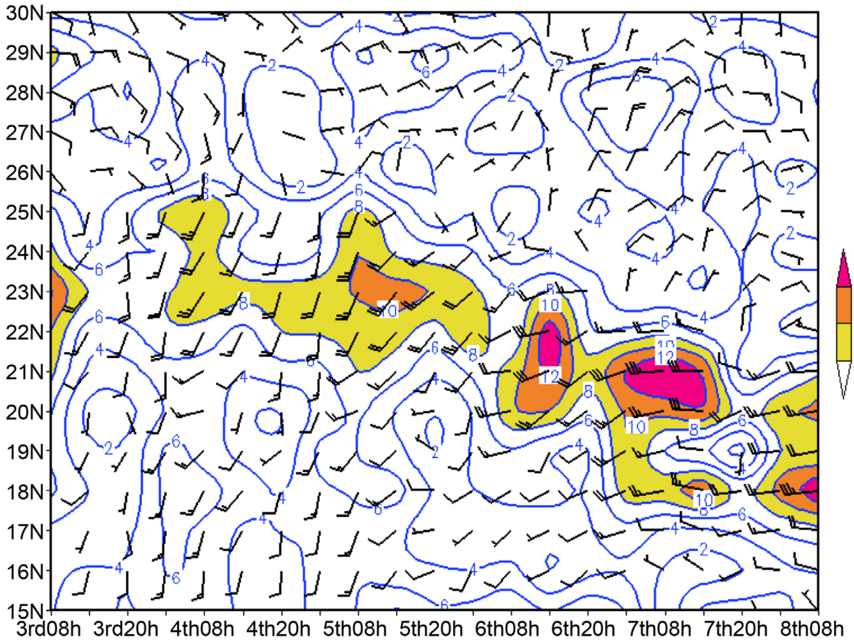


Figure 4. June 2014 3-8 day 850 hPa 110 degrees E full wind speed and wind field time profile(m·s^{-10}).

south of the subtropical high came across, thus strengthening the convergence of the upper moisture of the areas hit by the rainstorm.

Through analyses on the upper-level and low-level jet configuration, no low-level jet formed before 8:00 p.m. of June 4 and a weak southwest jet formed after

8:00 a.m. of June 5, while the intensifying east airflow and the two jets from the west and south of the subtropical high greatly intensified the rainstorm.

4.2. Water Vapor

The low-level water vapor channel of the troposphere and the densely distributed water vapor provide favorable water vapor and unstable conditions for the development of the convection system. According to the water-vapor flux field (figure omitted), there were two channels for conveying water vapor to the areas hit by rainstorms, including the southwest airflow from the Bay of Bengal and the south airflow from the Southern China Sea. The two channels enable water vapor and unstable energy to be conveyed upwards in a favorable dynamic condition, thus continuously providing water vapor and unstable energy for the occurrence and development of the rainstorm.

According to the profile map of the average divergence of moisture flux in the areas hit by the rainstorm (**Figure 5**), the convergence of water vapor intensified from 8:00 p.m. of June 3 and reached the top at 8:00 a.m. of June 5; the development and intensifying of the convergence of water vapor correspond to the periods of heavy rain; when the water vapor convergence reaches the strongest level, the rain would become heaviest rains; when the water vapor flux becomes less, the convection system will also weaken; during the rainstorm, the 850 hPa water vapor convergence center was located in the north and central areas of

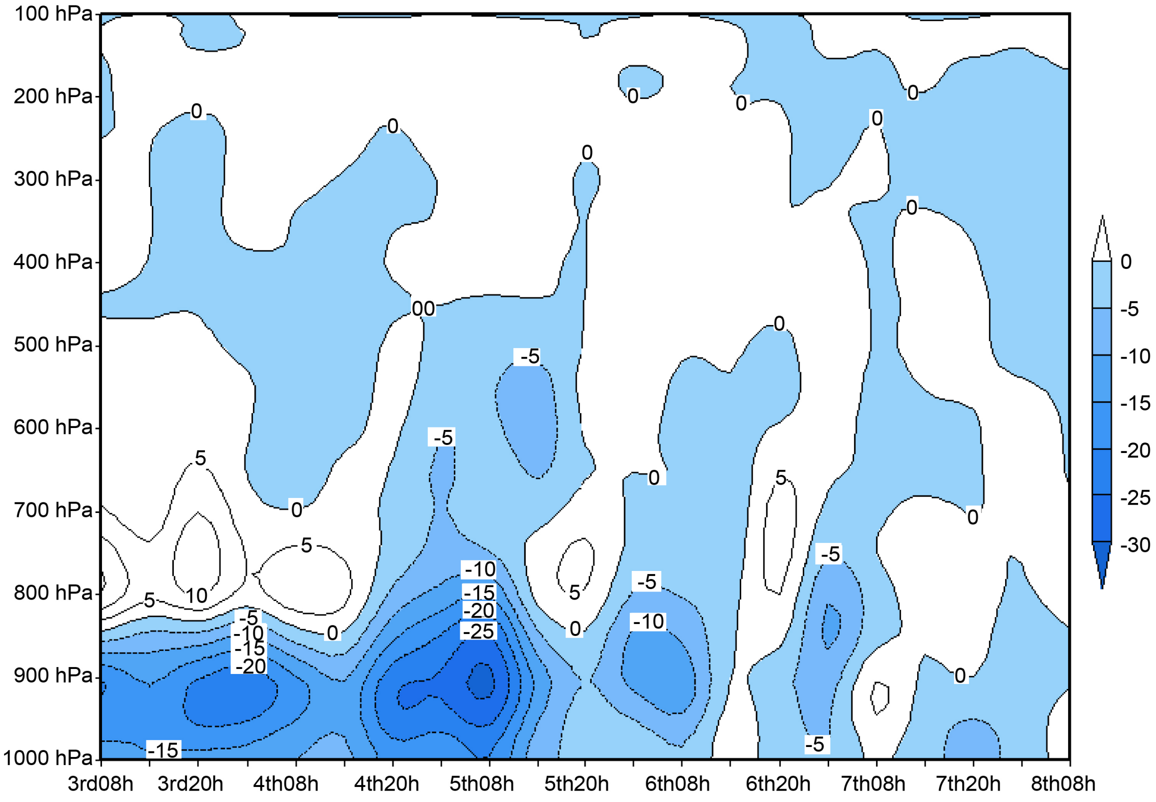


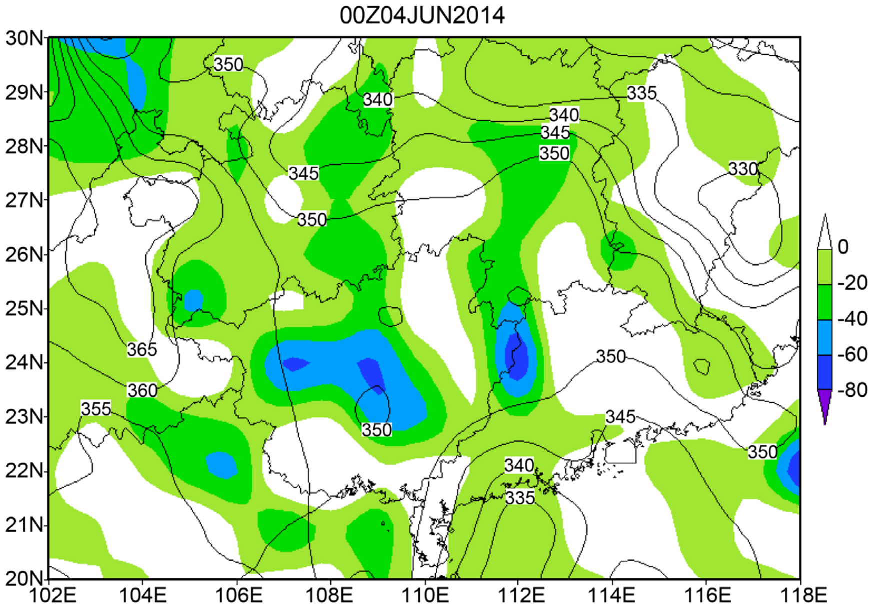
Figure 5. Regional mean water vapor flux divergence profile (10^{-6} g·cm^{-1}·hPa^{-1}·s^{-1}) (20˚N - 30˚N, 105˚E - 110˚E Average).

Guilin, and the water vapor convergence reached up to 500 hPa, during which the maximum intensify exceeded -25×10^{-6} g·cm^{-1}·hPa^{-1}·s^{-1}, thus playing an important role in contributing to the rainstorm and downpour in the north areas of Guilin.

4.3. Heat and Unstable Conditions

The instability caused by the difference in heat is the fundamental driving force for the formation of various weather conditions. Potential pseudo-equivalent temperature may reflect unstable energy to a certain extent. If the horizontal gradient of the low-level potential pseudo-equivalent temperature is large enough, there must be a strong-level energy front to contribute to the occurrence and development of convective weather. However, in the process of the rainstorm, there were no areas of large potential pseudo-equivalent temperature gradient and only a weak-energy front was located in the boundary of the northern Guangxi and the southern Guizhou (**Figure 6**). According to the distribution of the vertical speed, the high-speed areas well correspond to the heavy rain centers.

The overlay chart of the 850hPa potential pseudo-equivalent temperature and the vertical speed at 8:00 a.m. of June 4, 2014 is shown in the left of **Figure 6**. When cold air moved southwards, the energy front of the middle and lower reaches of the Yangtze River moved southwards to the boundary between the northern Guangxi and the southern Guizhou; centering on Yunan, there were two high-energy centers in the central Guangxi with east-to-west high-energy tongue; the areas of large vertical speed are located in the northwest and northeastern Guangxi; local strong ascending motion triggered the release of unstable energy. During the period from 8:00 p.m. of June 4 to 8:00 a.m. of June 5, there were two convective heavy precipitation centers in the northwest and northeastern Guangxi, where Donglan and Luzhai were hit by 106 mm and 208 mm heavy rains respectively; after 8:00 a.m. of June 6, the energy front moved



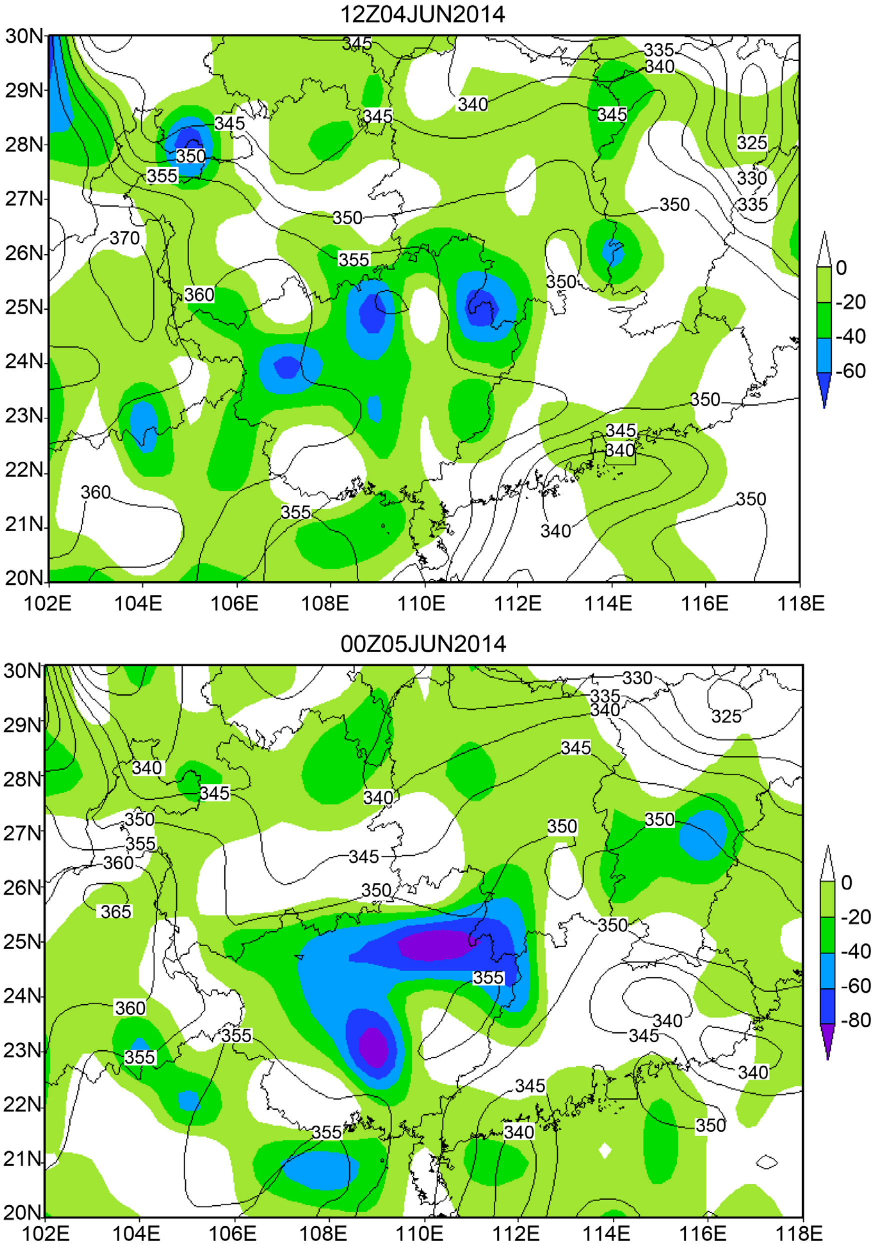


Figure 6. 850 hPa June 2014 4-5 pseudo equivalent temperature (K) and vertical velocity superposition diagram(Pa·s^{-1}) (solid line: pseudo equivalent potential temperature; stain: vertical velocity).

southwards with the intensity gradually weakening. Afterwards, the vertical speed reduced and the heavy precipitation weakened; until 8:00 a.m. of June 7, only the coastal areas were hit by heavy rains.

5. Analysis of the Characteristics of Meso-Scale Allobaric Field, Satellite Cloud Picture and Radar Return

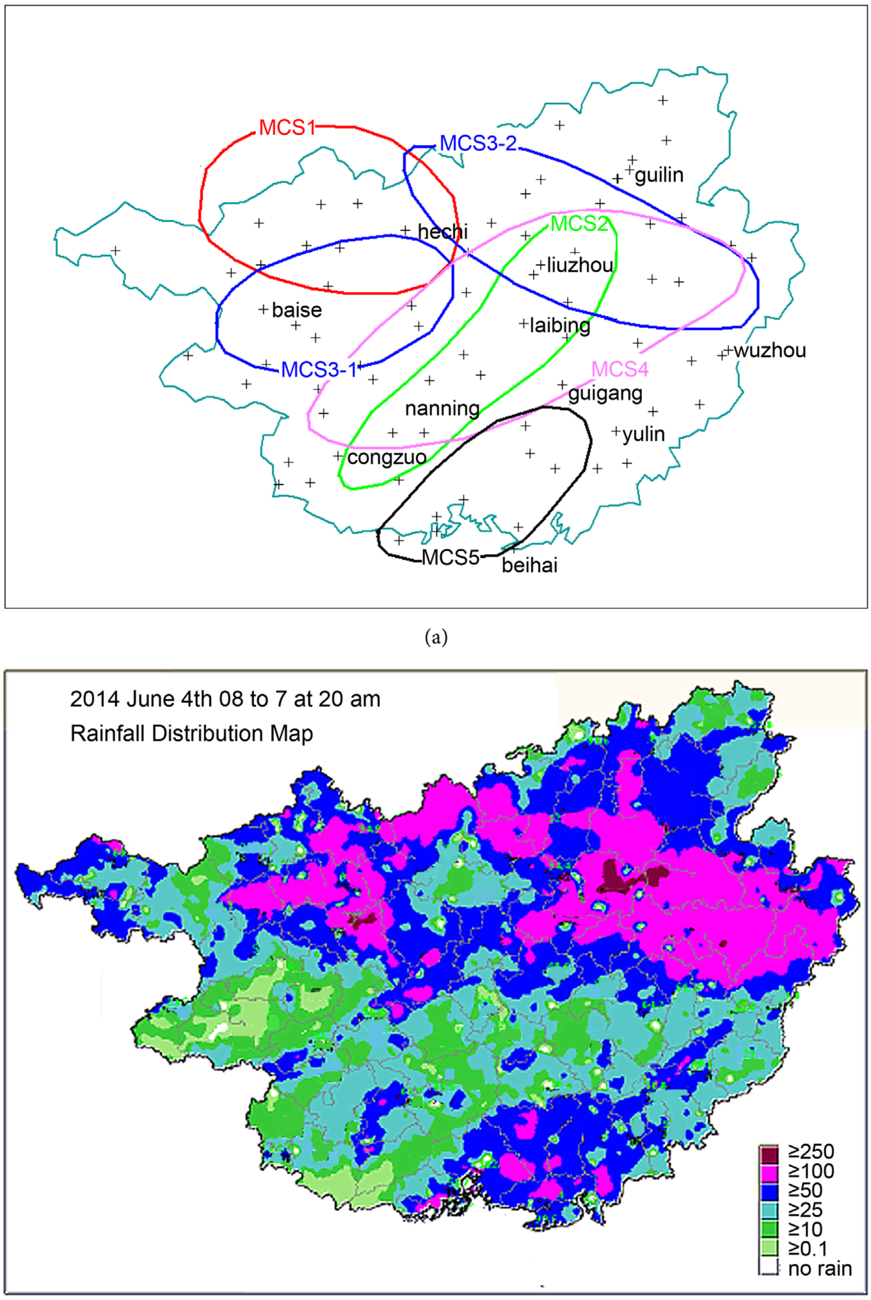
Studies show that meso-scale convective system (MCS) should be the main factor that led to the rainstorm during pre-rainy season in southern China. Through analyses and numerical simulation of the formation and development of MCS in the process of a rainstorm hitting the coastal region of southern China, Meng Weiguang [9] (2007) thought that the formation and development of convection and MCS were associated with topographic convergence and the mid-level disturbance respectively. Through analyses of the process of the convective rainstorm of quasi-stationary front triggered by weak cold air moving southwards from highland, Lin Zonggui (2014) [7] believed that, the invading weak cold air contributed to the re-formation of a quasi-stationary front, and the warm moist air accumulating in the katallobaric area triggered convection to form MCS and generate heavy rainfall after the front moved to the mesoscale katallobaric area [10]. However, before this continuous rainstorm, Yunnan, Guizhou and Guangxi were under the control of the southwest warm low pressure and no stationary front moved. To understand the relation between the invading weak cold air and the rainstorm, according to the non-conventional observation data of the mesoscale automatic meteorological station, satellite cloud picture and Doppler radar of Guangxi, analysis is made on the meso and micro-scale characteristics of the occurrence and development of the stationary front rainstorm [11] [12].

Through comprehensive analysis of satellite cloud picture, meso-scale allobaric field and radar return, there were 5 MCSs in Guangxi from 8:00 a.m. of June 3 to 8:00 a.m. of June 6, including MCS1 moving from 3:00 a.m. to 11:00 a.m. of June 4, MCS2 moving from 2:00 p.m. to 5:00 p.m. of June 4, MCS3 moving from 1:00 a.m. to 7:00 a.m. of June 5, MCS4 moving from 8:00 a.m. to 3:00 p.m. of June 5 and MCS5 moving from 1:00 a.m. to 5:00 a.m. of June 6, thus resulting in a heavy rain throughout Guangxi.

Due to the difference in the occurrence time, development intensity and range of motion among the 5 MCSs, there are also differences among the distribution of heavy rains in Guangxi (**Figure 7**). In **Figure 7(a)**, when MCS1 and MCS3-1 overlap, the Fengshan (209 mm) centered rainstorm area forms in the northwest Guangxi; when MCS2, MCS3-2 and MCS4 overlap, the rainstorm area centering on Luzhai (272.4 mm), Lizhai (224.6 mm), Mengshan (236.1 mm) and Zhaoping (218.0 mm) forms in the central and eastern Guangxi; due to MCS5, the Qinzhou (112.3 mm) centered rainstorm areas form in the southern Guangxi; the 5 MCS motions form 3 rainstorm centers shown in **Figure 7(b)**.

Based on characteristics of the 3 rainstorm centers caused due to the 5 MCSs, through analysis of the relation between the meso-scale aliobar and the development and movement of MCSs, it will be helpful to understand the process of the convective rainstorm of the stationary front triggered by weak cold air.

From 0:00 a.m. to 8:00 a.m. of June 4, meso-scale allobaric field was distributed from east to west on a high-to-low basis (**Figure 8(b)**), northerly wind prevailed in the anallobaric area of northeast Guangxi, while southeaster prevailed in the katallobaric area of northwest Guangxi; there was shear of wind direction and wind speed in the anallobaric area and the katallobaric area, thus providing a mesoscale condition for the occurrence and development of the convective rainstorm. From 3:00 a.m. to 11:00 a.m. of June 4, the first MCS



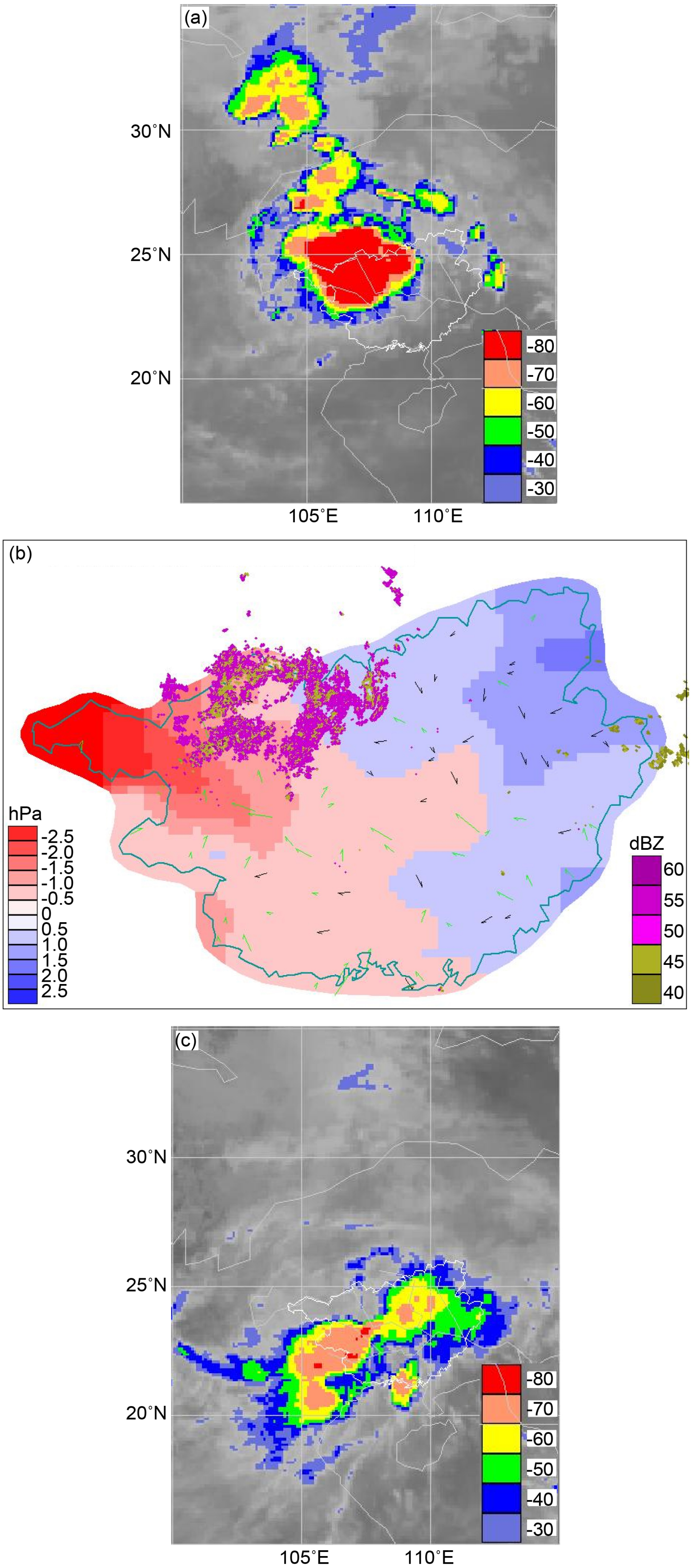
(a)

(b)

Figure 7. June 3, 2014 08-6 day MCS activity range and rainfall distribution of Guangxi in 08 (a): MCS life history schematic; (b): 2014 June 4th 08 to 7 at 20 am Rainfall distribution map).

formed due to the convection in the katallobaric area of the northwest Guangxi. When the MCS1 became mature and moved to the northwest Guangxi (**Figure 8(a)**), the first heavy rain occurred.

MCS1 weakened after 8 consecutive hours. Under the impact of the "thunderstorm high" [13] [14] generated due to the downward flow, the intensity of the katallobaric area of northeast Guangxi also reduced. From 2:00 p.m. to 5:00 p.m. of June 4, the effect of the "thunderstorm high" weakened, and the intensity


(a)
30°N
25°N
20°N
105°E
110°E
-80
-70
-60
-50
-40
-30
(b)
hPa
-2.5
-2.0
-1.5
-1.0
-0.5
0
0.5
1.0
1.5
2.0
2.5
dBZ
60
55
50
45
40
(c)
30°N
25°N
20°N
105°E
110°E
-80
-70
-60
-50
-40
-30

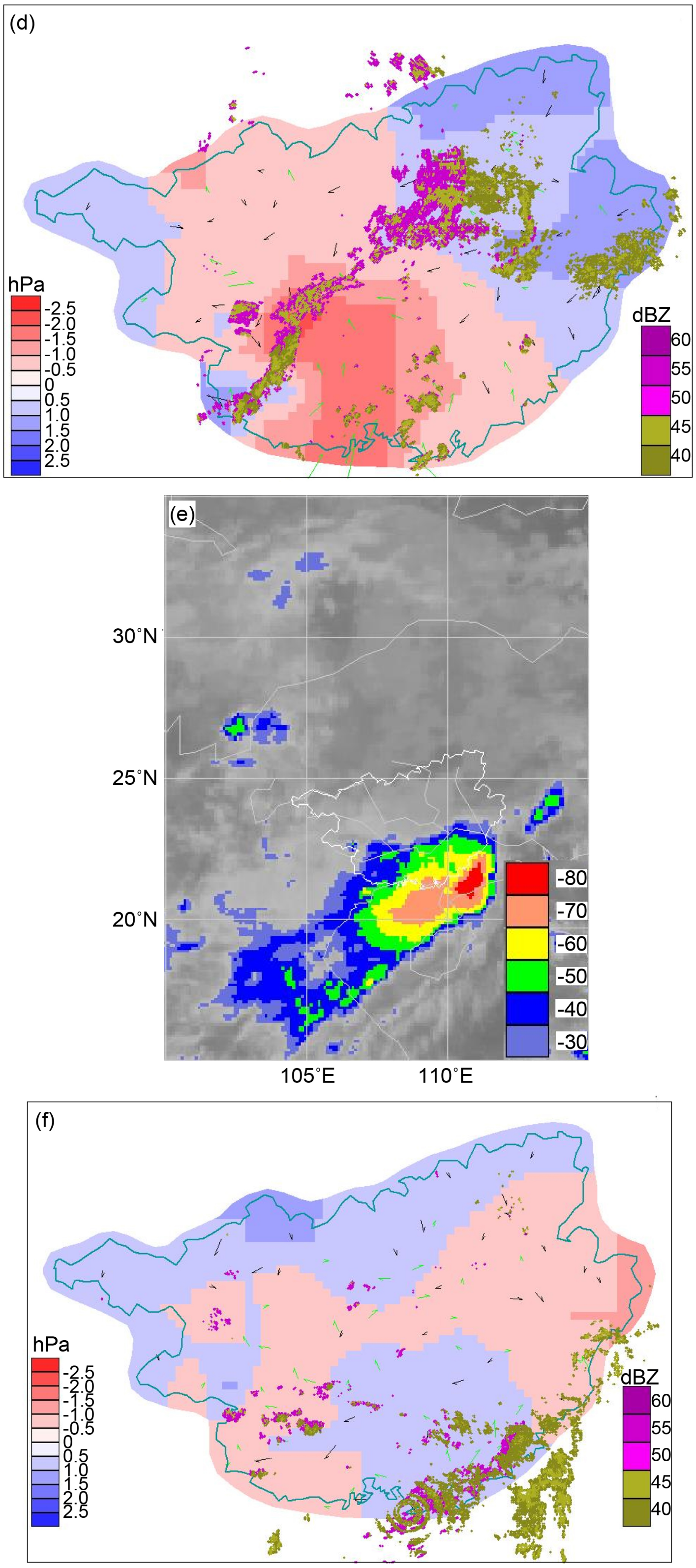


Figure 8. Satellite images and the pressure change and combination of anti radar echo rate (more than 40 DBz). (a): 8 am at June 6th04 Cloud chart; (b): 8 am at June 6th04 Pressure change and combined reflectivity factor; (c): 7 am at June 6th05 Cloud chart; (d): 7 am at June 6th05 Pressure change and combined reflectivity factor; (e): 5 am at June 6th06 Cloud chart; (f): 5 am at June 6th06 Pressure change and reflectivity factor.

gradually recovered, forming a zonal katallobaric trough from southwest to central Guangxi, in which line convection occurred and developed to form MCS2 (indicated with green in **Figure 7**). As a result, the second heavy rain occurred but lasted for a short time and hit the areas of a range less than MCS1.

MCS3 formed after the southwest jet. From 1:00 a.m. to 7:00 a.m. of June 5, the third MCS formed in the katallobaric area of northwest Guangxi (**Figure 8(c)**) and the convection developed in the center of the katallobaric area and the boundary wind shear zone (**Figure 8(d)**), forming two parts and MCS3-2 (indicated with blue in **Figure 7(a)**), of which MCS3-1 was located in the center of the katallobaric area and MCS3-2 was located in the wind shear zone. Both the two moved eastwards to jointly lead to the third rainstorm. When MCS3-1 and MCS1 overlap, a Fengshan (209 mm) centered rainstorm area formed in the northwest Guangxi.

From 8:00 a.m. to 3:00 p.m. of June 5, MCS4 emerged in the southwest-to-northeast elliptic katallobaric area (indicated with pink in **Figure 7(a)**); in such case, the echo moved northeastwards, and convective cloud radar echo initially clusters and distributes in an linear manner in the late stage, leading to the fourth heavy rain; when it overlaps with MCS2 and MCS3-2, a rainstorm area centering on Luzhai (272.4 mm), Lipu (224.6 mm), Mengshan (236.1 mm) and Zhaoping (218.0 mm) forms in the central and eastern Guangxi.

From 1:00 a.m. to 5:00 a.m. of June 6, the southwest-to-northeast strip MCS5 formed due to the developing convection in the coastal region of Guangxi as a mesoscale convective cloud cluster. During the initial MCS5 development stage, the mesoscale pressure gradient was small in the coastal region and only weak katallobaric area emerged in the coastal region of southern Guangxi. Until 5:00 a.m. of June 6, the intensity of the area significantly increased and a southwest-to-northeast linear convective radar return emerged (**Figure 8(f)**), thus leading to the fifth heavy rain.

6. Conclusions

1) This rainstorm formed in the event of the convection of a stationary front triggered by the southward moving weak cold air from the east of the northwest district and highland when the 500 hPa subtropical high weakened and moved southeastwards, the south trough moved eastwards, the 850 hPa shear line moved to the junction between Guizhou and Guangxi and the low-level southwest jet intensified under the background of circulation of two ridges and one trough at the 500 hPa Asian-European mid-high latitude.

2) After the 200 hPa upper-level jet stream moved westwards from east, low-level jet core gradually formed at 850 hPa, contributing to the rise of low-level water vapor convergence, upper-level divergence and continuous vertical ascending motion and thus leading to the continuous rainstorm.

3) After the intrusion by weak cold air of the meso-scale katallobaric area formed by the accumulated warm moist air of Guangxi before the intrusion, the warm moist air rose to trigger convection; convection cells developed and spread

nearby the boundary between anallobaric area and katallobaric area; with the anallobaric area moving southwards, MCSs developed in the anallobaric area which forms or intensifies 2 - 5 hours earlier than MCSs.

4) The rainstorm occurred due to the 5 MCSs in the large-scale environmental condition of southwest vortex extending to the low trough or upper-level shallow trough. A rainstorm center formed at the parts where the MCSs overlap. The evolution of the cloud system in the satellite cloud picture reflects the large and meso-scale characteristics in the process of forming and developing MCSs, each of which will experience the process from development and maturity to decline.

Through the weather diagnosis and mesoscale analysis of the stormy weather process, the causes of the heavy rainfall process and the mesoscale convective system characteristics of the persistent short-term heavy rainfall are discussed. And provide an analytical basis for further understanding of the static front convective rainstorm triggered by the weak cold air in the plateau, so as to form a forecast for business applications and learn from the experience, to enhance the predictability of rainstorms and to reduce the resulting losses.

Acknowledgements

This work is supported by Guangxi Natural Science Foundation (Project Task Number 2015GXNSFAA139235), China.

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