DEBRIS FLOWS: Disasters, Risk, Forecast, Protection

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S.S. Chernomorets, K. Hu, K.S. Viskhadzhieva

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Conference logo is based on a figure from S.M. Fleishman's book on Debris Flows (Moscow: Geografgiz, 1951, p. 51).

Weather background analysis of debris flows in southeastern Guizhou, China

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Abstract. In southeastern Guizhou Province, China, a devastating debris flows occurred on June 18, 2022, where entire house was swept down and washed away. Using a variety of meteorological observation data to analyze the weather background of this process, the results show that: the debris flow disaster was caused by a short period of extraordinary rainstorm. The 24h precipitation of the two heavy rain centers in the southeast of Guizhou Province was 359.2 mm and 312.5 mm, which appeared in Congjiang County and Rongjiang County, where the debris flow occurred. The rainstorm process was convergent frontogenetic rainstorm. 500 hPa short-wave trough with low level shear line and ground convergence line to provide sufficient power conditions. The low-level Southwest jet stream continues to deliver water vapor as it increases instability. The wet layer is deep and the water vapor condition is good. The specific humidity of 500 hPa, 700 hPa and 850 hPa is 6 g/kg, 11 g/kg and 16 g/kg, and the temperature dew point difference is 0–0.3°C. The temperature difference between 700 hPa and 850 hPa and 500 hPa is 15°C and 22°C. Cape is 189 J/kg. Various models, such as European Central, South China Model and Grapes_3km, have captured the rainstorm process. The rainfall forecast for central Europe is northward and the intensity is weak. Grapes_3km forecasts the center of heavy rain in Congjiang County, but the intensity is also weak, which has the best forecast effect on location and intensity.

Key words: *debris flow; weather background; heavy rainfall*

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Анализ погодных условий формирования селевых потоков на юго-востоке Гуйчжоу, Китай

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Аннотация. В юго-восточной провинции Гуйчжоу (Китай) 18 июня 2022 г. произошел разрушительный оползень, в результате которого были снесены и смыты все дома. Результаты анализа погодного фона этого процесса по данным метеонаблюдений показывают, что оползневая катастрофа была вызвана интенсивным ливнем. Количество осадков, выпавшее за сутки в двух уездах (Конгцзян и Жунцзян) на юго-востоке провинции Гуйчжоу, составило 359,2 и 312,5 мм. Здесь произошел сход селевых потоков. Ливень носил фронтогенетический характер. Коротковолновая ложбина 500 гПа с линией сдвига на низком уровне и приземной линией конвергенции обеспечивают достаточные условия для питания. Низко расположенное юго-западное струйное течение продолжает подавать водяной пар, увеличивая нестабильность. Влажный слой глубокий, и состояние водяного пара хорошее. Удельная влажность на высотах 500, 700 и 850 гПа составляет 6, 11 и 16 г/кг, а разница температур точки росы составляет 0–0,3°C. Разница температур между 700–850 и 500 гПа составляет 15 и 22°C. Мыс составляет 189 Дж/кг. Различные модели, такие как Европейская центральная, Южно-Китайская модель и Grapes_3km, зафиксировали процесс ливня. Прогноз осадков для центральной Европы – северный, интенсивность слабая. Grapes_3km

прогнозирует центр сильного дождя в уезде Конгцзян, но интенсивность также слабая, что имеет наилучший прогноз по местоположению и интенсивности.

Ключевые слова: *селевой поток, погодный фон, ливень*

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Introduction

Guizhou is a mountainous province, the occurrence of geological disasters is especially prominent, it is a high-risk area of geological disasters in our country, the precipitation concentration is the main inducing factor of the formation of major geological disasters, the major types of geological disasters in Guizhou are mainly landslides, small-scale debris flows have occurred in Lewang Town, Wangmo County, Southwest China in the past decade. On September 6, 2017, due to heavy rainfall (186 mm), in the northern Xintun Subdistrict of Wangmo County Xintong seat and in the Jiaotong – Russia area of Lewang Town, a debris flows geological disaster occurred. The loose debris flow accumulation blocked culverts in the local highway and village road, and the traffic in some areas was interrupted, the production and living of the local people caused a serious impact, resulting in varying degrees of property losses. On August 27, 2014, a landslide occurred in the Dabo Mountain opposite the Xiaoba Formation in Yingping village, Daoping Town, Fuquan City, due to rain water immersion, about 1.4 million m^3 rock slides at a speed of 50 m/s towards the phosphate rock at the bottom of the mountain. The pit is about 30 m deep and the water in the pit is about 50,000 m^3, which forms a tsunami-like high-pressure wave and debris flow, the debris flow covered an area of nearly 1 km^2 with an average depth of nearly 5 m and a maximum depth of 50 m, forming a Landslide dam river of nearly 5,000 m^2. On June 6, 2011, in the Yaojiawangou Valley of Xiaomi Valley, Xintun Town, Wangmo County, the slope of the inner wave tree suddenly slipped and disintegrated into a clastic deposit, which was about 200 m long, 50 m wide and 4.0 m thick, the volume of the deposit is about 4.0 x 10 m. Under the action of heavy rainfall, the loose deposits were transformed into debris flows which washed out the gullies, destroyed 7 houses and buried several mu of farmland. Heavy rainfall is an important cause of debris flow in Guizhou province. In this paper, multiple meteorological observations were used to analyze a disastrous debris flow disaster in southeastern Guizhou province on June 18, 2022, the weather background of debris flow is analyzed in order to provide some scientific basis for the prediction and early warning of debris flow in Guizhou province.

Sources of information

The data used in this paper are as follows: 1 the surface data are 24-hour precipitation data and hourly precipitation data from 84 national meteorological stations in Guizhou Province, the time range is from 2000 h on June 17, 2022 to 2000 h on June 18, 2022 (same as other data). The data source is the meteorological big data cloud platform (Tianqing). 2Micaps data are 3-hour sea level pressure field and surface mapping data, 08:00 and 20:00 500 hPa, 700 hPa, 850 hPa height field, temperature field, high altitude mapping data and T-lnp sounding data, the data source is micaps distributed data. 3 satellite data is the infrared channel data of Fengyun-4 geostationary weather satellite at a time interval of 15 min, and the data source is the national satellite meteorological center.

Actual characteristics of rainfall

On June 18, 2022, there were 145 stations of heavy rain, 88 stations of heavy rain and 12 stations of heavy rain along the east-west line in southern Guizhou province, the heaviest

rainstorm centers were mainly located in Congjiang County and Rongjiang County in the southeastern part of the province. The 24-hour rainfall was 359.2 mm in Qiaoxi County and 312.5 mm in Gaoma County in Congjiang City, Rongjiang Province, 96.7% of the heavy rainfall occurred near the debris flow disaster (Fig. 1).

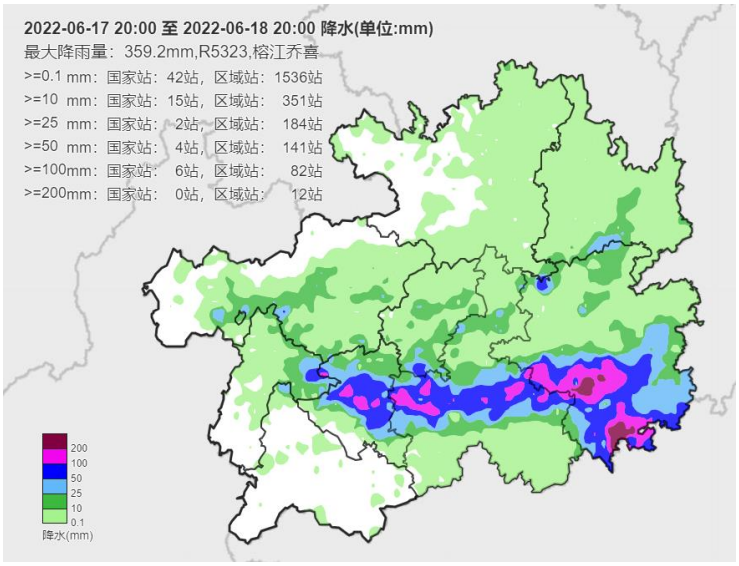

Fig. 1. Rainfall distribution map of Guizhou province on June 18, 2022

According to the hourly rainfall distribution map of the two heavy rainfall centers, the heavy rainfall lasted for a very long time, and the short-term heavy rainfall above 20 mm/h lasted for nearly 10 h, mainly occurred from 02:00 on the 18th to 11:00 on the 18th, the strongest at 05:00 to 08:00. It can be seen that not only the area around the debris flow occurred in a wide range of heavy rainfall, and heavy rainfall for a long time (Fig. 2).

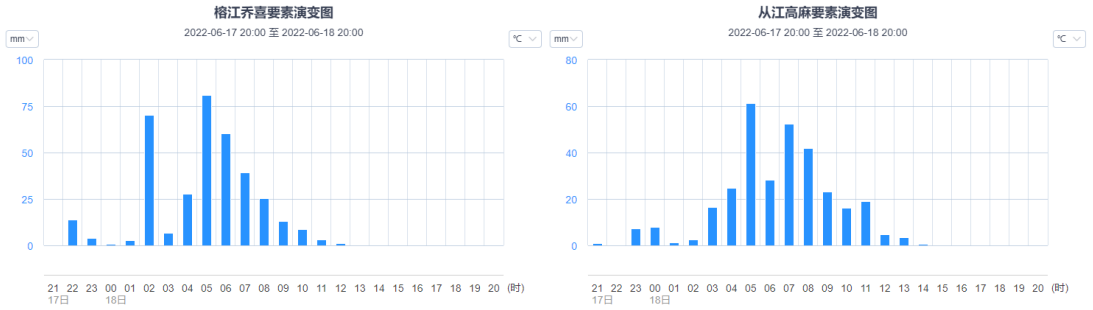

Fig. 2. Hourly rainfall distribution at 2000 h on June 17, 2022 to 2000 h on June 18, 2022

Weather situation analysis

At 20:00 on the 17th, a short-wave trough passed over Guizhou and moved to the eastern part of the province. The debris flow occurred in the updraft area in front of the trough. At 700 hPa, there was a southwest jet from central Guangxi to southern Hunan with a wind speed of 12–20 m/s, there is an 850 hPa shear line in the southeast of Guizhou Province, and a low-level southwest jet with wind speed of 12–16 m/s exists from Guangxi province to Fujian Province. There is an obvious convergence line of stationary front on the ground in the southern part of the province. 700 hPa and 850 hPa in Guizhou province are in the obvious wet area, the water vapor condition is very good, the specific humidity of 500 hPa, 700 hPa and 850 hPa are 6 g/kg, 11 g/kg and 16 g/kg respectively, the difference of temperature and dew point is 0–0.3℃ (Fig. 3).

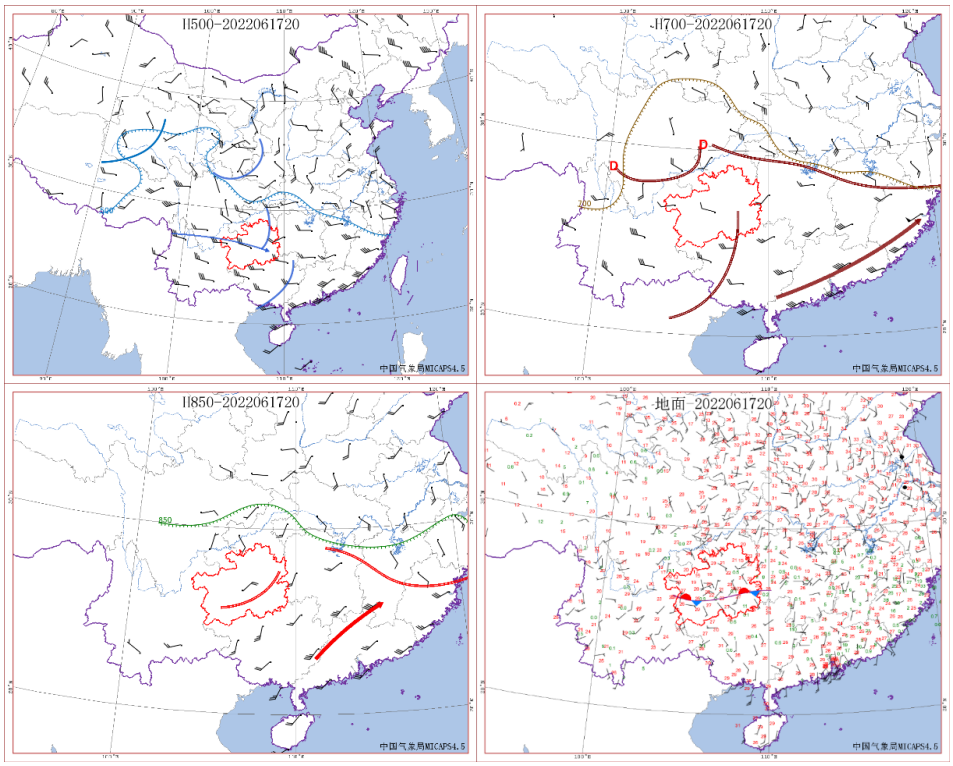

Fig. 3. 500 hPa (a), 700 hPa (b), 850 hPa (c) and ground (d) weather patterns

This process provides sufficient dynamic conditions for the front-type rainstorm of convergence line, 500 hPa short wave trough, low-level shear line and surface convergence line, the low-level southwest jet increases the instability and continuously transports water vapor.

A sounding map of Guiyang and Hechi at 2000 h on 17 June 2022 (Figs. 4 and 5) shows that both Guiyang and Hechi have a deep wet layer, while Guiyang has a deep wet layer from the ground to 550 hPa and Hechi has a deep wet layer from the ground to 350 hPa, the difference of temperature between 700 hPa and 850 hPa and 500 hPa is 15°C and 22°C, respectively. The shape of the sounding map is a narrow and long shape with obvious short-term strong precipitation. Cape in Guiyang is 189 JKG, Cape in river basin is 859 JKG, the conditions of water vapor and unstable stratification are both available. The presence of wind at the lower levels rotating clockwise with altitude and warm advection will further increase the instability of the atmospheric stratification. The height of uplift condensation and free convection is very low, which is very conducive to the occurrence and development of convective storms.

Forecast deviation analysis

The comparison between the forecast and the field shows that the European center is more accurate in predicting the 850 hPa wind field and the ground wind field at 20:00 on the 17th. The southwest jet, the shear line and the wet zone at 850 hPa are all predicted, but the location of the southwest jet was forecast to the north, the strength was forecast to be strong, the shear line was also forecast to the north, the surface front was forecast to the north.

According to the rainfall forecasts made by the European Center for many times for this heavy rain process, there has been a steady forecast of precipitation of more than an order of magnitude in the southeastern part of Guizhou Province, and the scope of the heavy rain has become bigger and bigger. The heavy rain center has continuously pushed northward and westward, has been steadily predicting. The European Center forecast of the heavy rain process is basically accurate and slightly weaker.

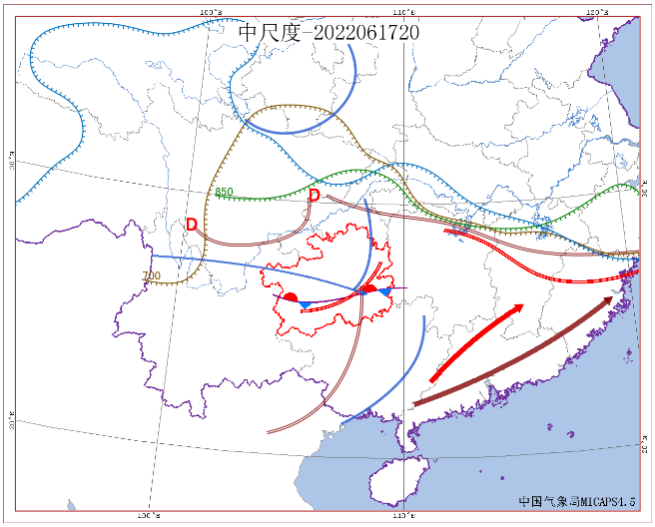

Fig. 4. Analysis at 2000 h on June 17, 2022

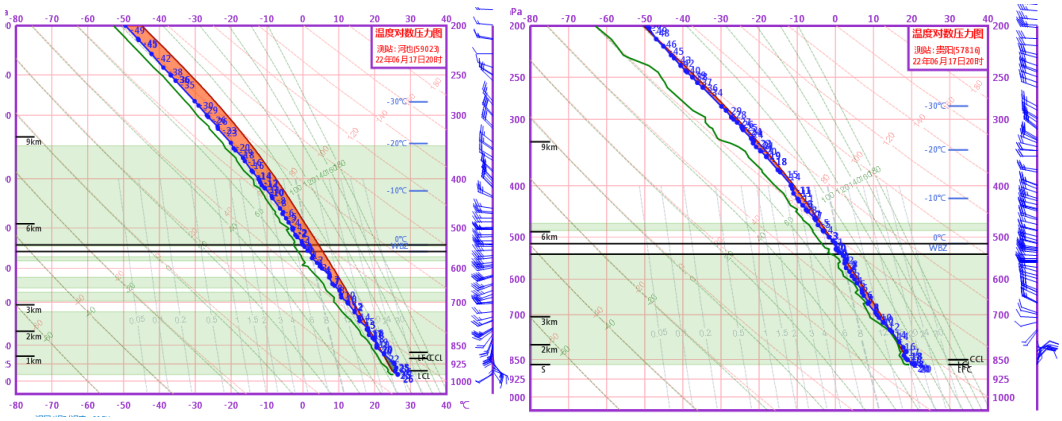

Fig. 5. Radiosonde map of Guiyang and Hechi at 2000 h on 17 June 2022

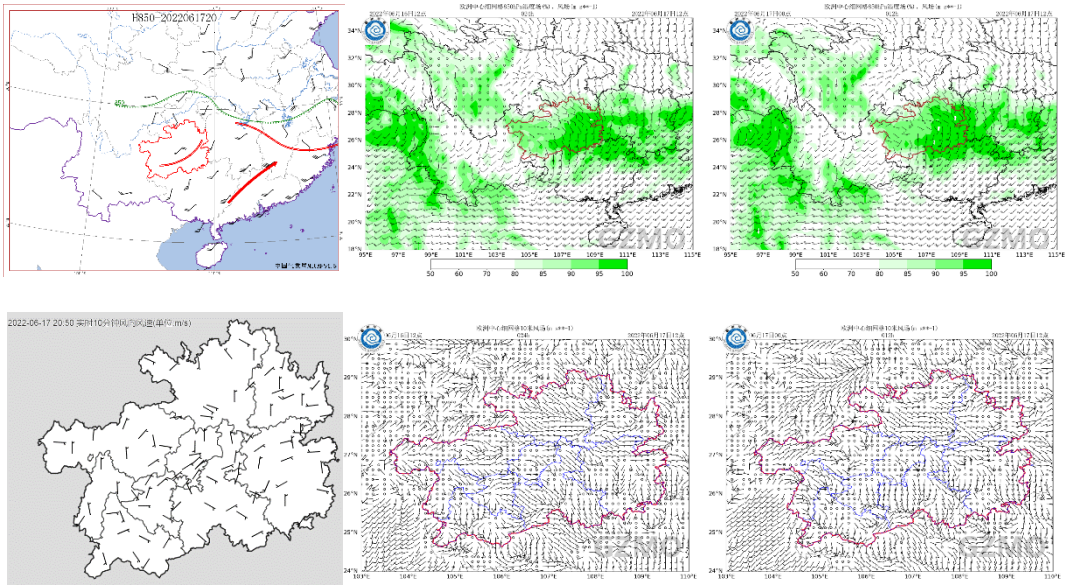

Fig. 6. 162 000 h (b, E-RRB-, 170 800 houCs Fc,Euroe Centrentre 850 hPa and ground forecast field and 172 000 h live field Da, d)

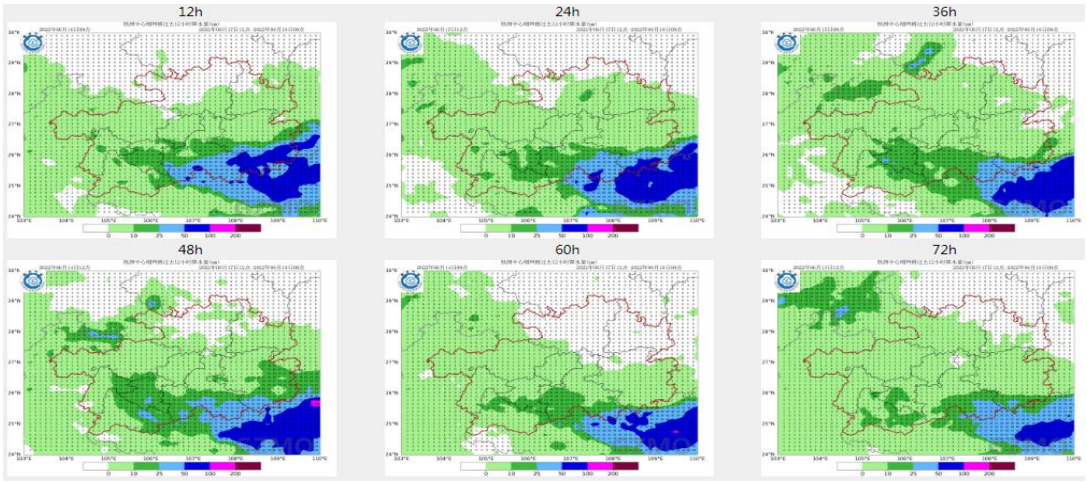

Fig. 7. European Center forecast 17th night rainfall map

The South China model has also forecast heavy rain in the central and southern parts of Guizhou Province, and the heavy rain falling area is generally consistent with the actual situation. In the central and southern parts of Guizhou province, the location of the heavy rain center on the west side is basically consistent with the actual situation, and the forecast of the heavy rain center on the east side is more westward than the actual situation, the forecast of rainstorm intensity is weak, only the magnitude of rainstorm is forecasted, and the actual situation has appeared the extremely heavy rainstorm.

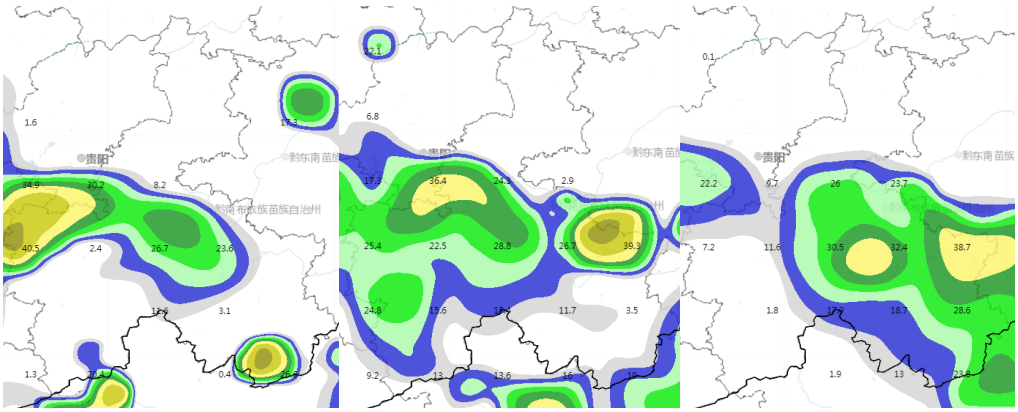

Fig. 8. South China model forecast 17th night rainfall chart

The Grapes radar combination albedo forecast also predicted the convective storm in the area east-south of the central part of the province. The forecast of the strong Echo Center in the eastern part of the province is basically consistent with the actual situation.

The European Central Fine Grid, the South China model, Grapes and other models all captured the heavy rainfall process. The European central fine grid forecasts the northern part of the heavy rainfall area and the intensity is weak. The Grapes location and intensity forecast is the best, in Congjiang County, the center of heavy rain was forecast, but the intensity was also weak.

Conclusion

1. The debris flow disaster was caused by the extremely heavy rainfall in a short time. The 24-hour precipitation of the two extremely heavy rainfall centers in the southeast of Guizhou province were 359.2 mm and 312.5 mm respectively, in Congjiang and Rongjiang counties, where the debris flows occurred.

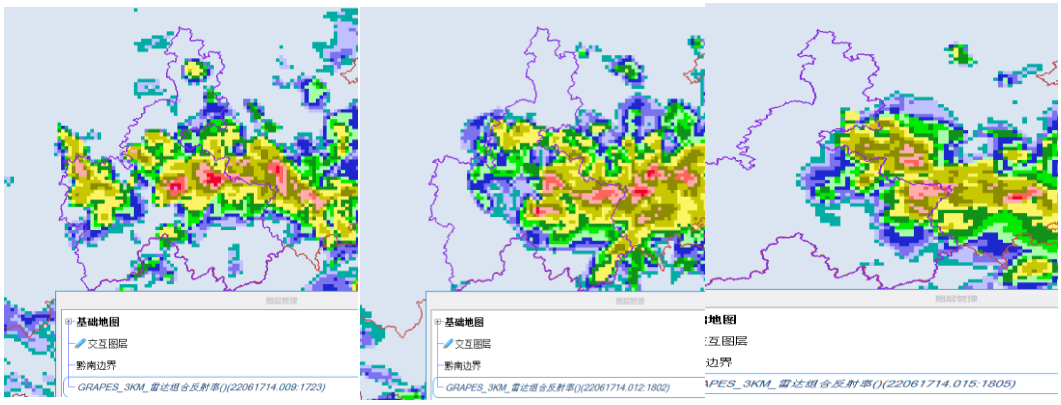

Fig. 9. Grapes Forecast 17-day night radar echo

2. This process provides sufficient dynamic conditions for the front-type rainstorm of convergence line, 500 hPa short wave trough, low-level shear line and surface convergence line, the low-level southwest jet increases the instability and continuously transports water vapor.

3. The wet layer is deep and the water vapor condition is very good. The specific humidity of 500 hPa, 700 hPa and 850 hPa is 6 g/kg, 11 g/kg and 16 g/kg respectively, and the difference of temperature and dew point is 0–0.3℃. The temperature difference between 700 hPa and 850 hPa and 500 hPa are 15℃ and 22℃ respectively. Cape at 189 J/kg.

4. The European Central Fine Grid, the South China model, Grapes and other models all captured the heavy rainfall process. The forecast of the European central fine grid heavy rainfall area is northward and the intensity is weak, and the location and intensity of Grapes are the best, in Congjiang County, the center of heavy rain was forecast, but the intensity was also weak.

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