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Analysis of the Causes of a Low Cloud and Low Visibility Weather at Cangyuan Washan Airport

Yahan Zhong[1,2*], Wancheng Zhang[1,2], Juzhang Ren[1,2], Man Wang[1,2], Yun Tao[1,2]

[1]Yunnan Institute of Meteorological Sciences, Kunming, China
[2]Research Center for Disastrous Weather in Hengduan Mountain and Low-Latitude Plateau, CMA, Kunming, China
Email: *yahan1996@163.com

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Abstract

At 11:00 am on August 5, 2017, Cangyuan Washan Airport experienced low cloud and low visibility weather, accompanied by aircraft turbulence, which affected the normal operation of flights, which was closely related to the meteorological conditions at that time. Using the hourly reanalysis data of the European Centre for Medium-range Weather Forecast (ECMWF) Reanalysis 5 (ERA5), including Geopotential height, temperature, precipitation, wind field, specific humidity, vorticity and other elements, with a spatial resolution of 0.25˚ × 0.25˚, this paper focuses on the horizontal distribution and vertical configuration of various physical quantities before and after the occurrence of low cloud and low visibility weather at the airport. The results indicate that the main influencing system of this low cloud and low visibility weather is the westward tropical depression. Before the occurrence of low cloud and low visibility weather, low-level water vapor converges and is accompanied by precipitation. The temperature decreases with precipitation, the near-surface wind direction changes, and the wind speed decreases.

Keywords

Low Clouds, Low Visibility, Vertical Velocity

1. Introduction

Cangyuan Washan Airport is located in Cangyuan County, Lincang, Yunnan Province, at 23˚9'48"N, 99˚13'21"E, with an altitude of 1839.8 m. The airport is located at the western edge of the Yunnan-Guizhou Plateau, with the terrain generally high in the west and low in the east. The runway extension line is located in the northeast-southwest trough. Due to the special terrain of Cangyuan Washan Airport, it is rare to see continuous heavy fog weather, but the situation

that some fog formed by low cloud lifting blocks the runway threshold in the northeast is more frequent. According to statistics, from January 2017 to April 2023, the most important weather that affects the flight of Cangyuan Washan Airport is low cloud and low visibility weather, followed by severe convection weather (Table 1). Low cloud and low visibility weather mainly occurs in July, August, and October (Table 2).

Table 1. Annual statistics of flights affected by important weather in Cangyuan Washan Airport from 2017 to 2023.

Year	Thunderstorm	Strong wind	Low cloud and low visibility weather	Rainfall	Strong convection
2017	1	2	33	2	
2018	1		67	6	5
2019			30		9
2020		4	47	5	1
2021		1	48		7
2022			16		2
2023					
Sum	2	7	241	13	24

Table 2. Monthly statistics of flights affected by important weather in Cangyuan Washan Airport from 2017 to 2023.

Month	Thunderstorm	Strong wind	Low cloud and low visibility weather	Rainfall	Strong convection
1			11	2	
2			4		2
3	1		2		
4			10		1
5			10		
6	1		17	4	6
7			37	5	3
8			52	2	6
9		6	8		9
10		1	58		
11			16		
12			16		
Sum	2	7	241	13	24

Low cloud and low visibility weather is a dangerous weather phenomenon that has a serious impact on aircraft safety. The main reason why low clouds affect aircraft flight is that during takeoff and landing, if there are low clouds in the sky, especially in large areas, it can cause serious visual obstruction. Low clouds will cover the airport and other surrounding buildings, and when landing, the pilot may be at a low altitude from the ground when passing through the clouds, unable to align with the runway in time. If such a situation occurs, the aircraft will not be able to land safely, and the solution can only be to go around. Low visibility causes pilots to have blurred vision, unable to effectively distinguish surface obstacles, navigation aid light indications, etc., resulting in potential risks such as aircraft deviation or running off the runway, which may lead to serious safety accidents. Many scholars have made statistical analyses on aviation high-impact weather, and some scholars have also made a case analysis of low cloud and low visibility weather for a single airport [1]-[7]. However, there is little analysis of the weather of the airport in Yunnan, let alone the Cangyuan Washan Airport, which has only been built for a few years.

2. Materials and Methods

Considering the continuity and completeness of the data, this article selects flight data from January 2017 to April 2023. The flight data used in this paper is from the daily statistics of the meteorological station of Cangyuan Washan Airport.

Using the hourly reanalysis data of the European Centre for Medium-Range Weather Forecasts ERA5, including geopotential height, temperature, precipitation, wind field, specific humidity, vorticity and other elements, with a spatial resolution of 0.25˚ × 0.25˚, the statistical analysis method is adopted, and the horizontal distribution and vertical configuration of various physical quantities before and after the occurrence of low cloud and low visibility weather at the airport are emphatically analyzed.

3. Analysis of Synoptic Scale Situation

On August 5, 2017, from 6:00 to 12:00, the main center of the South Asian High Pressure was located near (32˚N, 92˚E), and the ridge line was located near 32˚N (**Figure 1**). The airport was affected by the southeast-northeast wind of the South Asian High Pressure, and the wind speed remained at 15 m/s.

In the 500 hPa circulation field, the Eurasian continent is of two troughs and one ridge type. There is a weak high trough to the west of Yunnan, and a low-pressure system is maintained in the southwest of Yunnan. Cangyuan Washan Airport is located to the north of the low-pressure system (**Figure 2**). At 6:00 pm and 9:00 pm, affected by the flow of the north of the low-pressure to the east, it turns to the northeast at 10:00 pm, and the wind speed is maintained at about 10 m/s.

4. Physical Quantity Field Analysis

Further analyze the effects of water vapor conditions, dynamic conditions, as

well as factors such as precipitation and wind on low cloud and low visibility weather. From the distribution of water vapor flux and water vapor flux divergence at 700 hPa, corresponding to 500 hPa, there is a low-pressure system that moves slowly to the west. Cangyuan Washan Airport is located in the northwest of the low-pressure system and is affected by the northeast airflow. At 09:00-12:00 in Cangyuan Washan Airport, the water vapor convergence is conducive to the formation of low clouds (**Figure 3**). There is a water vapor divergence zone in southern Yunnan gradually moving northeast.

From the precipitation point of view, Cangyuan Washan Airport had weak precipitation at 09:00-10:00 before the low cloud and low visibility weather, which could rapidly reduce the visibility, and there was no precipitation at 11:00 and 12:00 (**Figure 4**).

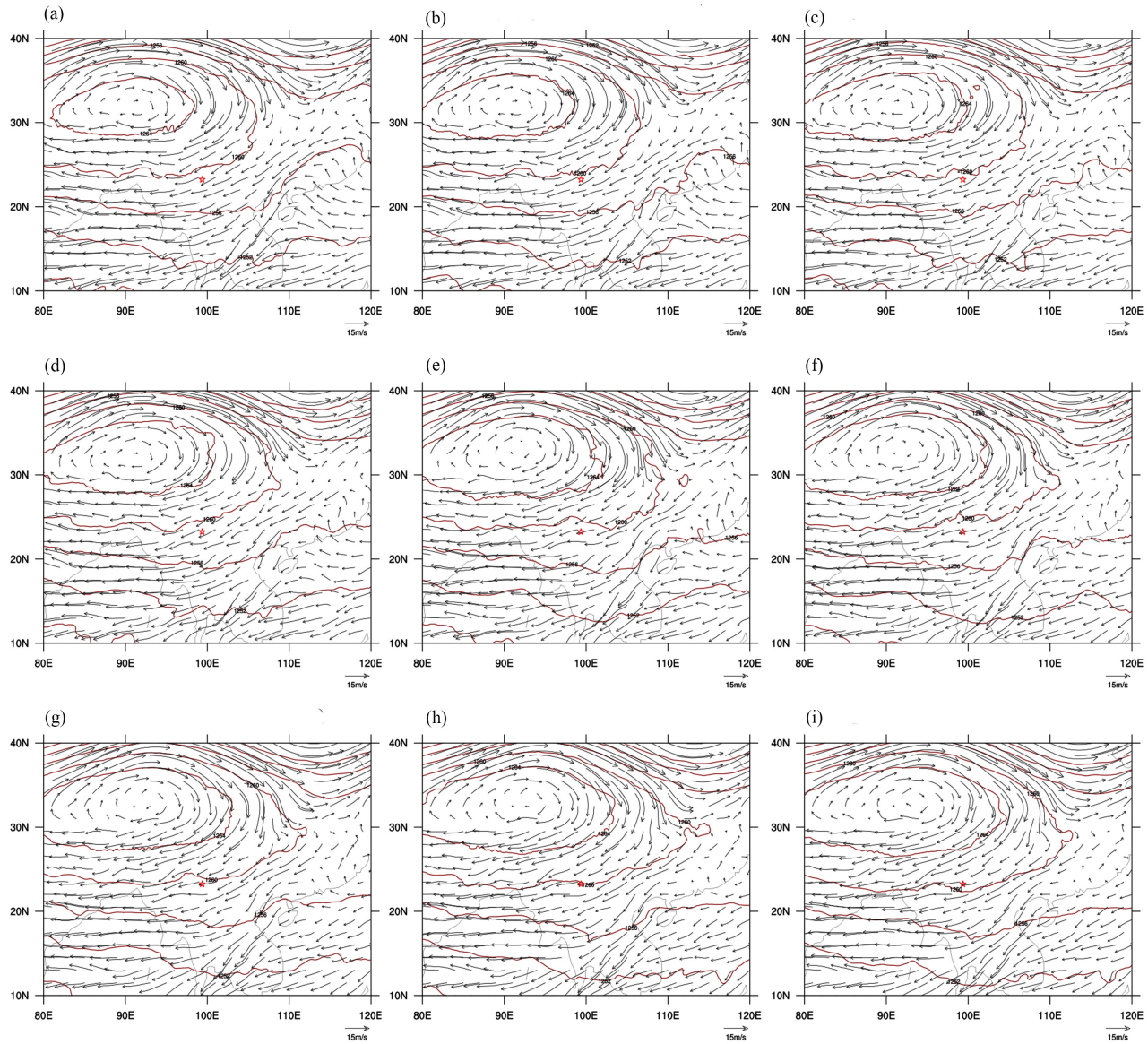

Figure 1. 200 hPa u and v wind farms from 6:00 to 14:00 on August 5, 2017 (the red star represents Cangyuan Washan Airport).

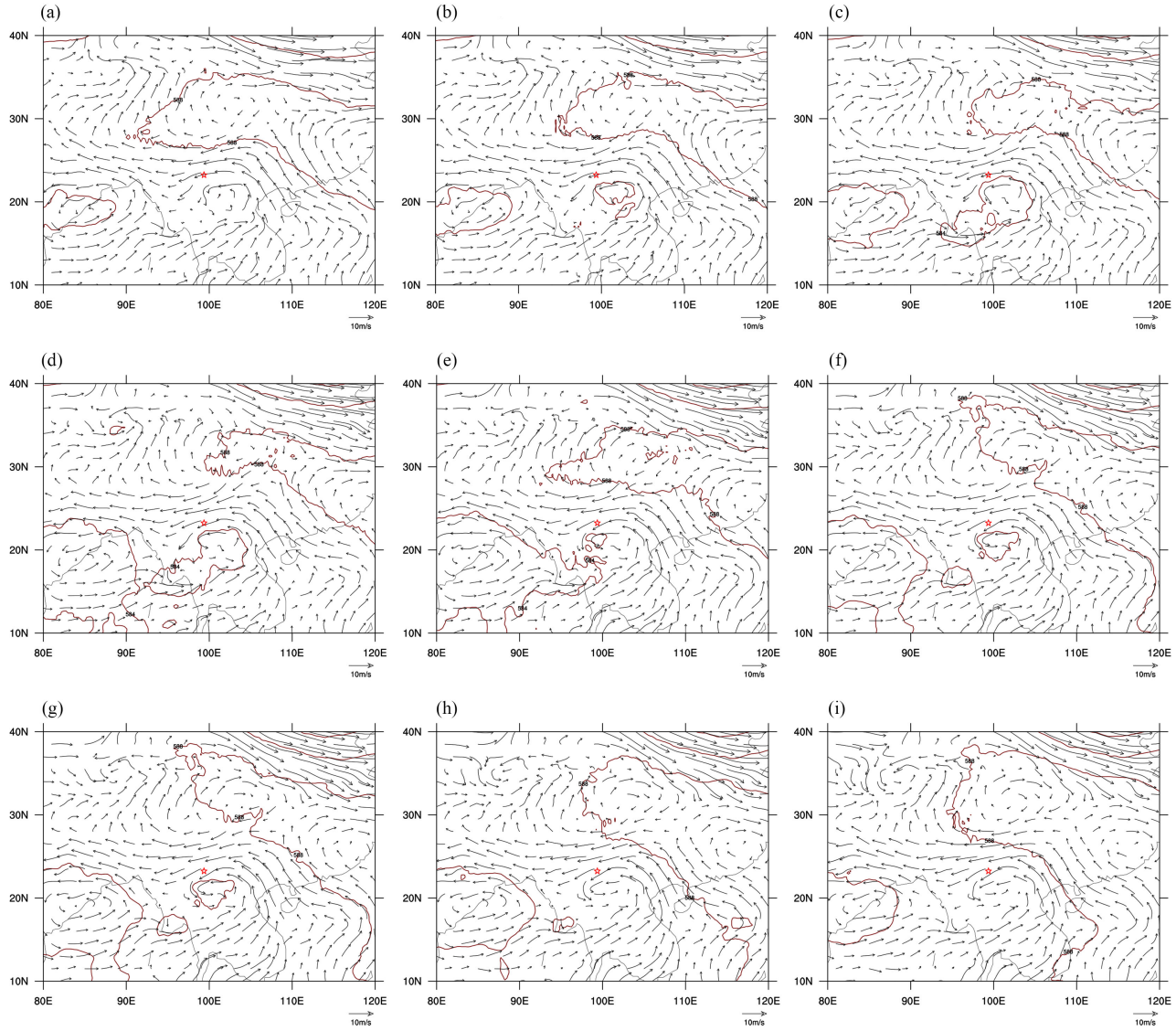

Figure 2. 500 hPa u and v wind farms from 6:00 to 14:00 on August 5, 2017 (the red star represents Cangyuan Washan Airport).

The wind speed of Cangyuan Washan Airport decreased from 3 m/s to 1 m/s from 06:00 to 11:00 on the 5th, and the wind direction changed from westerly to southerly, then westerly, and finally southerly, and the wind speed increased to 3 m/s at 12:00. The temperature drops with precipitation from 25˚C to 22˚C (**Figure 5**).

The crew reported that the aircraft was still experiencing turbulence while preparing for descent. When cold air arrives, the stronger the cold air, the greater the vertical velocity of its sinking, and the higher the horizontal wind speed at which the air reaches the near surface. At the same time, the sinking of cold air is also conducive to the downward transmission of momentum at high altitudes. When the wind speed at high altitudes increases, the ground wind speed will also increase due to the downward transmission of momentum [8] [9]. The time height vertical profile of vertical velocity was made for the nearest grid point (99.25˚E,

23.25˚N) of Cangyuan Washan Airport at 06:00-15:00 on August 5, 2017. It was found that there was obvious downdraft in the lower layer at 9:00 and 11:00 (Figure 6). At 06:00-08:00, there was a strong upward motion, with a maximum speed greater than 2 Pa/s. At 09:00, 250 - 700 hPa was accompanied by precipitation, resulting in a sinking motion. Under the influence of such vertical speeds, the aircraft is prone to turbulence.

From the longitude height vertical profiles of vorticity and vertical velocity along 23.25˚N at 9:00 and 11:00, it can be seen that there is obvious downdraft from 200hPa negative vorticity at Cangyuan Washan Airport (near 99.25˚E) at 9:00, low-level positive vorticity, and 98 - 100˚E from 200 hPa to near ground; At 11:00, weak downdraft also appeared over Cangyuan Washan Airport (Figure 7).

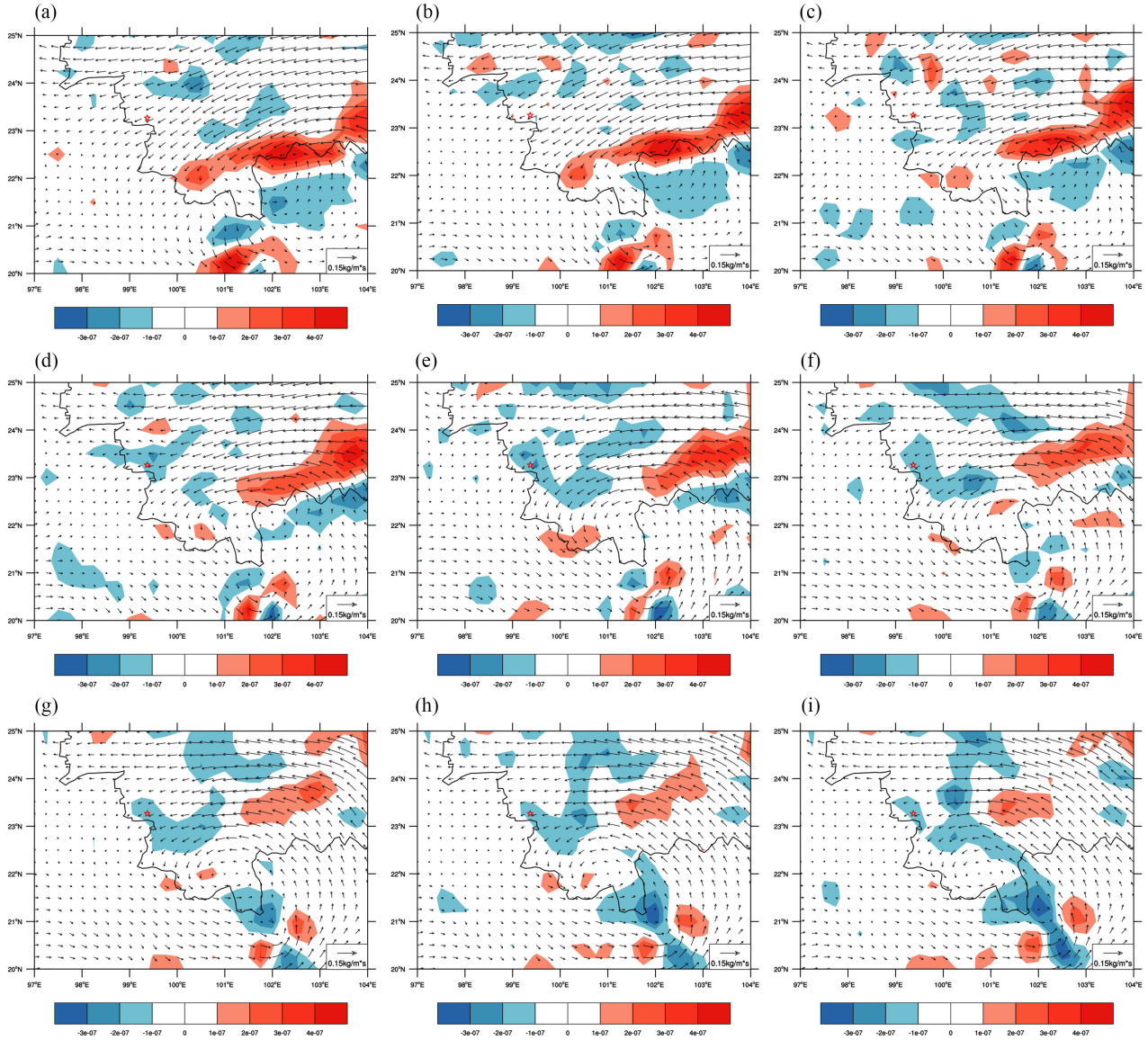

Figure 3. Water vapor flux and water vapor flux divergence field at 700 hPa from 6:00 to 12:00 on August 5, 2017.

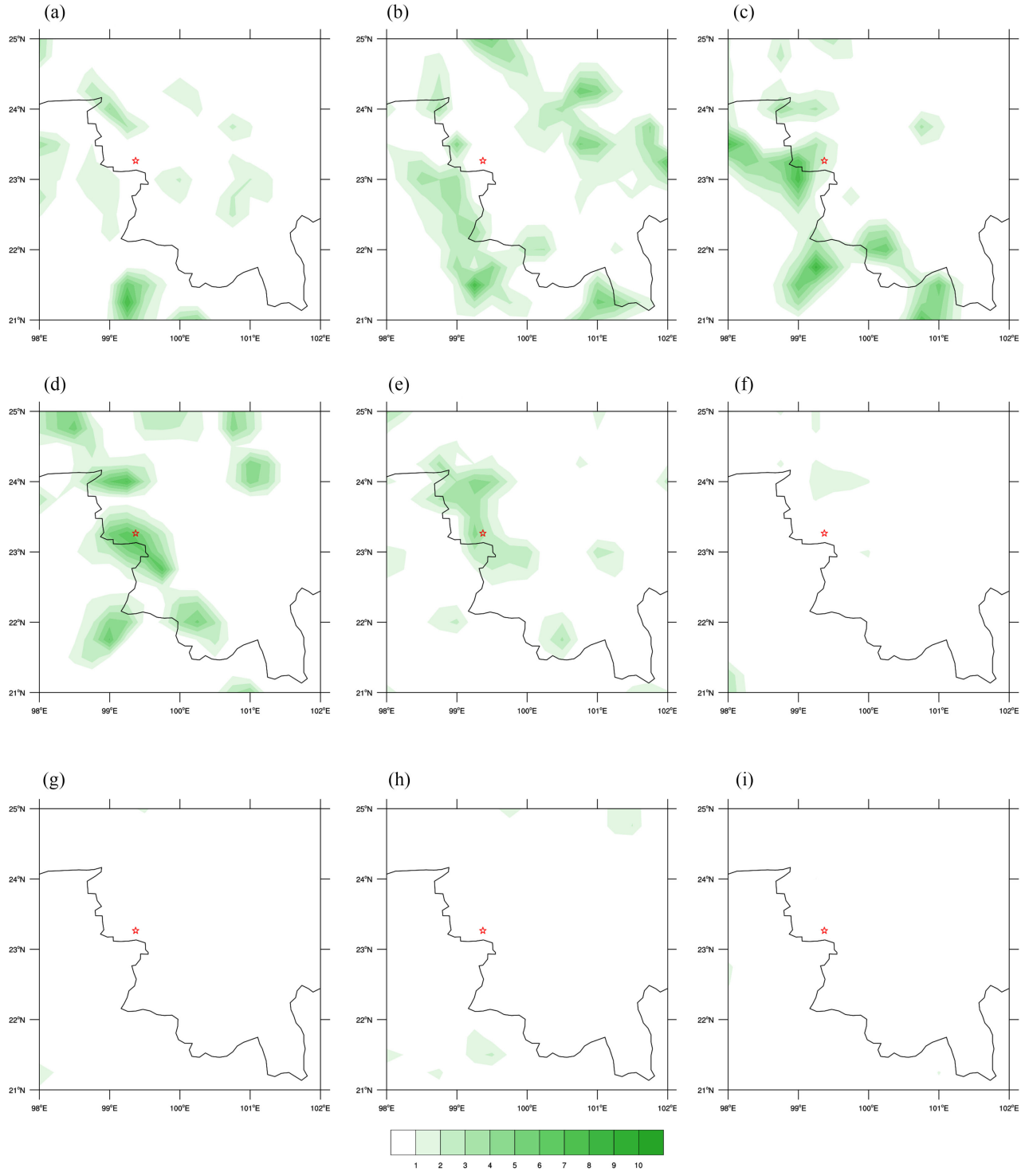

Figure 4. Precipitation distribution map on August 5, 2017 from 6:00 to 12:00.

5. Conclusions

From the above analysis, we can draw the following conclusions:

1) The main influence system of low cloud and low visibility weather on August 5, 2017 at Cangyuan Washan Airport is the westward tropical depression.

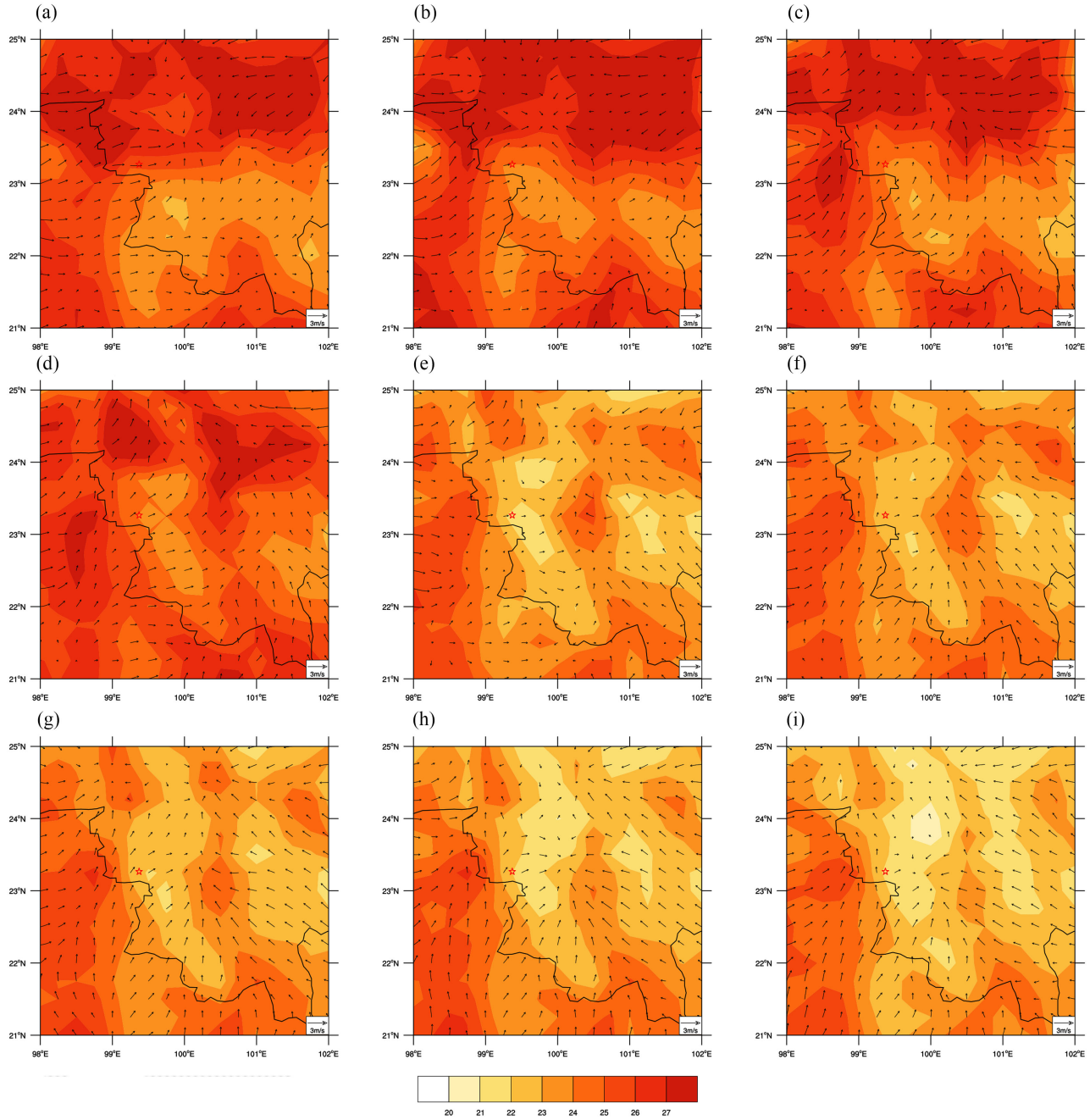

Figure 5. Surface temperature field and wind field on August 5, 2017 from 6:00 to 12:00.

2) Before the low cloud and low visibility weather in Cangyuan Washan Airport, there was water vapor convergence at 700hPa. The water vapor accumulates at the lower level, which is conducive to the formation of precipitation and low clouds. With the water vapor convergence, there is weak precipitation, which makes the visibility drop rapidly.

3) The temperature is accompanied by precipitation dropping from 25˚C to 22˚C, while the wind direction near the ground changes, and the wind speed decreases from 3 m/s to 1 m/s, which is conducive to the formation of low clouds.

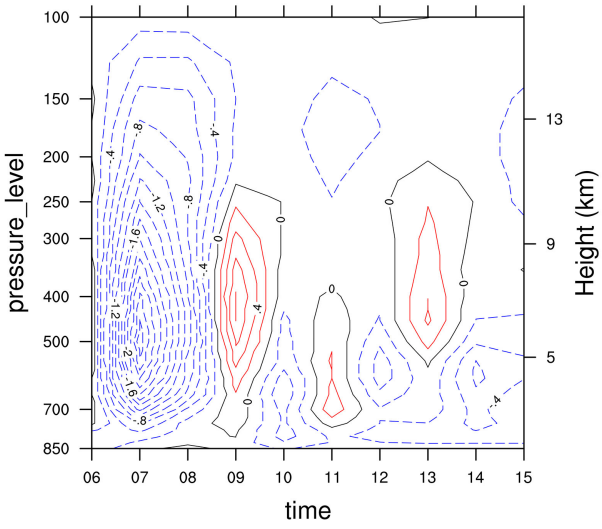

Figure 6. Time altitude vertical profile of vertical velocity at 6:00-12:00 (99.25˚E, 23.25˚N) on August 5, 2017. Unit: Pa/s. Timeline unit: Beijing time.

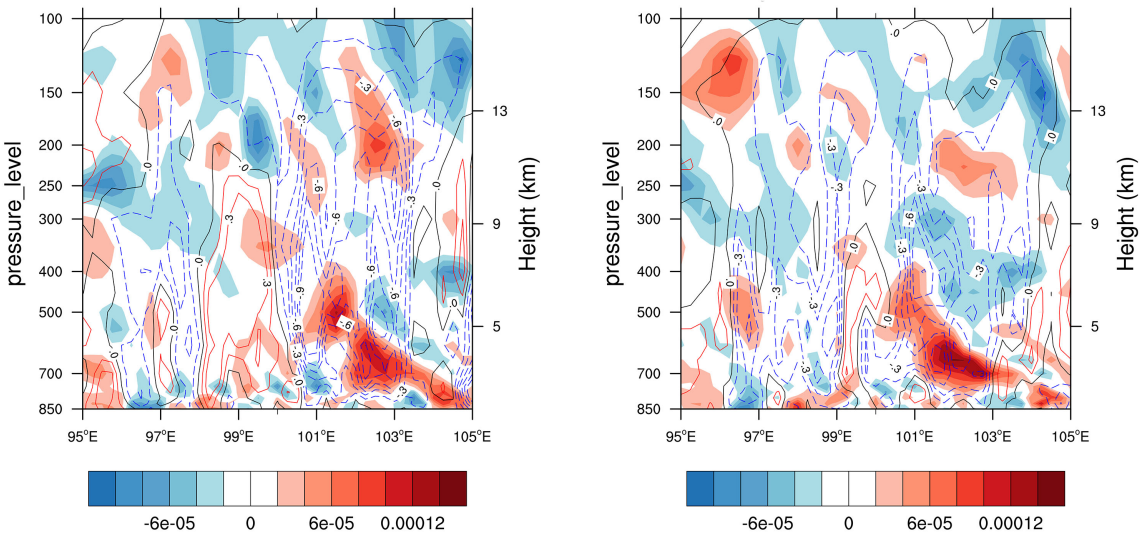

Figure 7. Longitude height vertical profile of vorticity and vertical velocity along 23.25˚N at 9:00 and 11:00 on August 5, 2017.

Acknowledgements

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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