Proceedings of the 2023 International Conference on Machine Learning and Automation
DOI: 10.54254/2755-2721/30/20230088

Development and application of Doppler climate radar

Baihao Wang

Beijing New Talent Academy, Beijing, 100000, China

1051779654@qq.com

Abstract. Extreme climates would make a difference in people's daily lives and threaten security. In order to regulate and lower the damage effectively, we ought to monitor these weather conditions accurately. Using weather radar to realize early warning and real-time monitoring of sudden catastrophic weather is of great significance and value. With the development of science and technology, weather radar has made some progress. In order to promote its further development, the present situation and development trend of weather radar are analyzed in this paper. Generally, a few developed states have already started to utilize this technique, and it will be popularized gradually. Basically, a few developed states, such as America, have already started to utilize this technique to forecast the climate. Even though this radar is not mature enough to accomplish the high aim, it will be popularized over time.

Keywords: Doppler climate radar, current condition, developing tendency.

1. Introduction

Weather radar is used to measure the location and course of storms and clouds. Weather radar originated from conventional weather radar. By observing the echo position and intensity of the target and the echo intensity change between successive pulses, weather radar can provide the spatial distribution of precipitation position and the change of precipitation intensity over a large range. It has long been an important detection tool for precipitation forecasts, severe convective weather warnings, and cloud physics research. At present, the typical modern weather radar uses Doppler technology. Doppler weather radar is a kind of radar that makes use of the Doppler effect formed by the relative motion between particles and the radar in scatterers such as clouds and rain. This radar can detect the position and intensity distribution of clouds and rain and the vertical and horizontal movement of particles inside the meteorological target. Since the formation, development, and dissipation of storms are related to the movement of internal particles, ordinary weather radar is unable to provide this important meteorological data. It is a major piece of equipment used in climate forecasting, but this paper will explore how this amazing tool operates based on physical theory.

2. Prinicple of Doppler Radar

Doppler weather radar is based on the Doppler effect. Meteorological Doppler radar detects motion in the atmosphere using the Doppler effect, which means that when an object moves toward or away from the radar, the frequency of the signal it emits or reflects changes. This change in frequency is called a Doppler shift. By measuring the Doppler shift, we can calculate the velocity and direction of the scattering object. Firstly, the meteorological Doppler radar can realize the real-time detection and

DOI: 10.54254/2755-2721/30/20230088

analysis of rainfall intensity and precipitation type. By analyzing radar reflectance factor, Doppler velocity, and other parameters, real-time tracking and prediction of precipitation systems can be realized, and timely warning information about thunderstorms and rainstorms can be issued, providing important support for disaster prevention and reduction. In addition, meteorological Doppler radar can scan at different angles and altitudes to obtain more comprehensive observations. At the same time, it can also change its measuring range and resolution by adjusting the pulse repetition rate and pulse width. By analyzing the frequency change of radar echo signal, the vertical and horizontal wind field information in the atmosphere can be obtained, so as to realize the description of storm structure and development trend. ”The new generation of Doppler weather radar has become one of the most important means to monitor and forecast severe weather and has been widely used in some developed countries around the world. China began to build a new generation of weather radar networks in 1998, and has included this project in the national debt fund support project. This paper introduces the development of Doppler weather radar technology, the construction and application of Doppler weather radar in our country, and puts forward some problems that should be paid attention to in the development and construction of radar technology in weather monitoring in the future.”[1]

In addition, meteorological Doppler radar can be combined with other meteorological observation means, such as satellites, weather stations, etc., to jointly carry out short-term approaching weather monitoring. For example, real-time monitoring and early warning of severe weather such as typhoons and rainstorms can be carried out by using satellite cloud images and meteorological station observation data, combined with the precipitation detection capability of Doppler radar. China has now begun to lead the way in the network method of numerical weather forecasting.

The application of the change network method in the numerical forecasting service in our country provides a scientific basis. However, compared with advanced countries such as Europe and the United States, the application level of special observation data in network systems (especially satellites and meteorological mines) is changing.

At the same time, there is still a big gap in the application of detection data in mines in China.

For example: Variational network techniques for obtaining radial wind (or radar wind corridor) observations are limited to variational assimilation of radar return intensity data for scientific exploration and case studies, with little success so far.

There are several instances of Doppler radar in China listed below.

“Changchun Doppler weather radar data was used to evaluate the two snowfall processes that occurred on December 16 and December 29, 2019. The results show that the warm advection has a long influence time, the warm advection comes into the ground near the ground, and the radial velocity or wind direction convergence characteristics are conducive to strengthening the snowfall process. The snowfall process will weaken when there is a cold advection intrusion near the ground. When the zero velocity line has a bend angle, the position and moving direction of the cold front can be determined with the radial velocity. When the Changchun Doppler weather radar detected the cold front, it indicated that the snowfall process in the central region of Jilin Province would weaken or move eastward.”[2]

“At 19:47 on June 8, 2018, hail weather occurred in Xining, with the largest hail diameter of 8mm. The hail weather process belonged to the northwest airflow type, but the intensity was weak, and the echo characteristics were not obvious on the weather radar in Xining, which was an atypical hail weather process in the eastern plateau. The analysis of conventional data and Xining Doppler weather radar data shows that: (1) the vertical stratification distribution of dry atmosphere and wet atmosphere breaks the vertical stratification stability, which is conducive to the increase of atmospheric instability energy. (2) The triggering effect of the ground convergence line is more obvious than the local thermal effect; the vertical upward movement of the atmosphere and the convergence of the middle and low levels are poor. The water vapor condition is poor. (3) The combined reflectivity of radar echoes is strong; radial velocity shows convergence at low elevation and divergence at high elevation. The top height of the echo is about 6-7km, and the convection is not deep. The vertical integral liquid water content is small and the range is small. (4) The height of the centroid of the strongest echo and the height of the storm core decreased significantly and rapidly, and the vertical integral liquid water content increased in a

DOI: 10.54254/2755-2721/30/20230088

small degree and range; The vertical profile shows that the high value areas of high, middle and low reflectivity factors overlap each other in the vertical direction. Although there is an echo wall, the intensity is weak, there is no obvious inclined structure, and there are no radar echo characteristics such as a weak echo region or bounded weak echo region in the vertical profile."[3]

"On June 1, 2015, Jianli County, Hubei Province, was affected by an extreme wind weather process (referred to as "6.1 Jianli Gale ") caused by a downburst, and the "Eastern Star" passenger ship overturned on the Yangtze River. The circulation background and influence system of the "6.1" monitoring wind process are analyzed using conventional observation data, encrypted automatic station data, radiosonde data, Doppler radar products, and NCEP reanalysis data. Based on the radar data, the formation reasons are emphatically discussed. The results show that: (1) strong low-level vertical wind shear and low convective condensation height are favorable conditions for its occurrence, and the development of surface mesoscale vorticity and cold front provide triggering mechanisms for it; (2) the "6.1" Jianli Gale was caused by a linear multi-cell storm, which was accompanied by supercells in the strong stage and resulted in a mesocyclone in succession. (3) After the storm cell develops into a supercell, the rotation speed of the mesocyclone increases gradually and the bottom height decreases continuously, which may be the precursor of tornado winds. (4) The extreme winds caused by the downburst that caused the crash of the Eastern Star (hereinafter referred to as extreme winds) were accompanied by the development of the large value region of low elevation velocity before and during the occurrence of extreme winds, and the mesocyclonic characteristics of the storm cells had weakened when the extreme winds occurred. In addition, the sweeping intensity reflectivity factor nuclei of five consecutive individuals had continued to decline before the extreme winds occurred. (5) Radar radial velocity products, storm attribute table products, and mesocyclone attribute table products have important reference values for "6.1" monitoring wind approaching warning, storm evolution trend, mesocyclone attribute table, and low elevation velocity large value area. All show certain indicative characteristics before the extreme wind."[4]

3. Future Development forecast

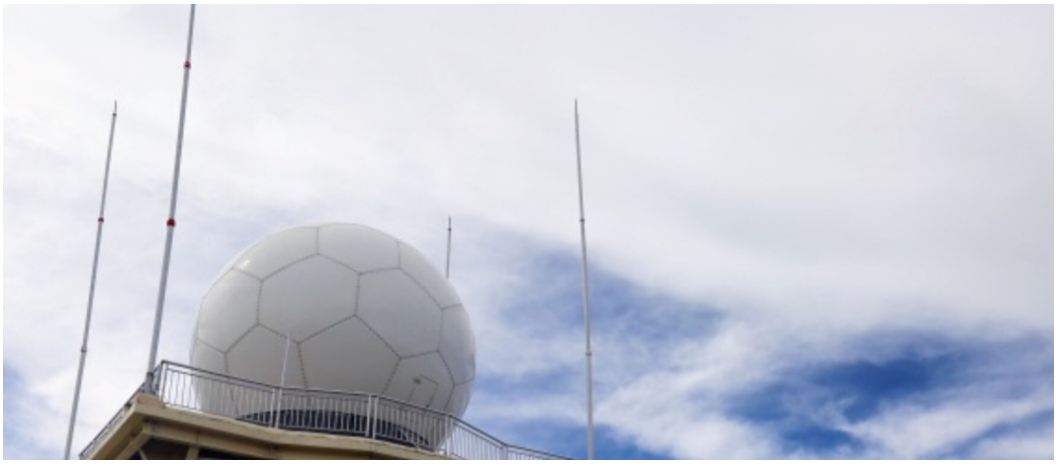

Figure 1. the brandnew Doppler Radar in China

Figure 1 shows the brandnew Doppler radar used in China. "The development of weather radar is based on the current research focus of atmospheric science. Mainly lies in research and response.
Use shorter space scales for small and medium scale climatology, as well as longer time scales for meteorology, so in weather radar

For a period of time in the future, Doppler weather radar will still be the main trend, and the Doppler weather radar technology will be further developed to expand the detection function. In the future, we can control and support each other."[5]

DOI: 10.54254/2755-2721/30/20230088

"The technique refers to the vertical beam of the antenna. A multi-beam system is formed to accurately monitor and provide early warning of several bursts.

The common disaster weather in China is mainly ice, short-term heavy precipitation, and storms. So in the future,

Further, strengthen the analysis of the error of X and the liquid section line error, and monitor the influence of the error.

The accuracy of the research and the future development of weather radar will expand the detection function and improve the accuracy

More attention has been paid to making breakthroughs in the study of new technology. Enable computing power and signal processing capability.

Force greatly lifted away. The Doppler wind field reverse clearing technology will require more in-depth research, and be fully used in the application and wind field.

The information is transformed from qualitative to quantitative by using single-doppler weather radar inversion technology."[6]

4. Conclusion

Doppler weather radar acts an significant role across the world. In order to use it expertly or study further, People ought to focus more on the practical application of Doppler radar instead of theory.

References

[1] Xu Xiaofeng. (2003). Construction and technical application of China's new generation Doppler weather radar network. China Engineering Science, 5(6), 8.

[2] Xu G, Sun J H, Lei J, Zhao S X. (2009). Doppler weather thunder The effect of Dregification on rain simulation . Journal of Applied Meteorology.20(1)

[3] Peiyuan, Z. . (1991). The characters of mesoscale structures near the trough line——analysis of doppler wind measurements. Meteorological Monthly.

[4] Radar group Doppler wind velocity analysis of Chinese Academy of Meteorological Sciences South 1990.1.

[5] Yang Bi. Chong. Experimental study of deassimilating Doppler weather radar data [J], Meteorology 28 (2)

[6] He Wei-dian, Wu Ren-Biao, Wang Xiao-liang. The impact assessment of wind farm on the equipment and the technology of thousands of willow production Journal of Electronics and Information Technology, 2017,39(7) : 1748-1758, 55