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Study on Urban Proximity Prediction Based on Doppler Radar Gust Front Characteristics and Urban Microclimate Characteristics

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Abstract: Based on the state response of fractional order singular linear systems with impulses, the sufficient and necessary conditions for complete controllability and observability of fast subsystems are studied and given, and the criteria for complete controllability and observability of fast subsystems are further established. These assumptions are too strong to synthesize the controllability of slow subsystems and fast subsystems. The method proposed in this paper does not need these assumptions, The approximate controllability of Hilfer fractional order integro differential equations is studied by using the order method. The controllability and observability criteria of the system described by fractional order differential equations are derived. When the rank of its controllability discrimination matrix M and observability discrimination matrix N is full, the fractional order system is controllable and observable.

Keywords: Controllability; observability criteria; fractional differential equations

1. INTRODUCTION

China is a country with frequent natural disasters, especially meteorological disasters. For civil aviation, the weather conditions directly affect whether the aircraft can fly normally. Known as "invisible killer" and "air trap", low-level wind shear is an atmospheric phenomenon that seriously affects aircraft flight. According to statistics, aircraft accidents caused by low-level windshear account for about 30% of aircraft takeoff and landing accidents. Compared with conventional digital weather radar, Doppler weather radar can directly measure radial velocity and velocity spectrum width. The analysis and application of radial velocity field has opened up a new field for weather prediction.

This paper will mainly use the data collected by Taiyuan's new generation single Doppler weather radar in recent years to analyze the characteristics of non-precipitation echoes before the generation and development of different scale weather systems; Through their identification and comparison with precipitation characteristics, we can further reveal the indicative significance of non-precipitation echoes in the near forecast. The core of the extrapolation method is to use the radar data to obtain the velocity vector respectively through the wind field inversion and the optimal correlation technology of adjacent time and sub-space and use the velocity vector to predict the location and range of the next echo. For a long time, hydrometeorological departments have mainly used raingauges to observe urban rainfall at point-scale.

The rain gauge can accurately measure the rainfall process at its location. However, even in cities with relatively dense rainfall stations, it is usually necessary to use a single observation result to represent tens or even hundreds of square kilometers of rainfall. As mentioned earlier, rainfall, especially the rainfall on the urban underlying surface, has great spatiotemporal variability, and this "point for surface" observation method often cannot well describe the spatial distribution characteristics of urban rainfall in theory, VVP can obtain nine variables, including mean wind field, divergence vorticity and gradient term of wind field. It is an ideal Doppler wind field retrieval method.

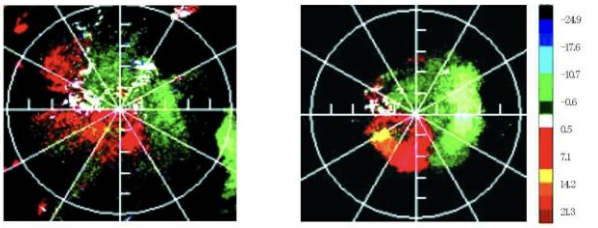

Figure. 1 Divergence non- precipitation echo on Doppler velocity field. (Sample image from search engine)

2. THE PROPOSED METHODOLOGY

2.1 Characteristics of Doppler radar gust front

In the actual calculation of nine variables, we will encounter the problem of ill-conditioned matrix, which seriously restricts the effective inversion of the vertical velocity field and other variables The superposition of cold and warm advection and divergence makes the area of negative velocity area on the non-precipitation velocity echo map smaller than that of positive velocity area; The azimuth difference between the two zero velocity lines on the equidistant circle and the positive velocity zone is greater than 180 b. These characteristics are completely consistent with the characteristics of large area precipitation on Doppler radar velocity map. It can be seen that the Doppler velocity image of non-precipitation echo is the same as that of large area precipitation, which better reflects the three-dimensional structure of the ambient wind at the station. The center of the initial array at time t1 of the array alignment is the starting point of the echo moving vector, and the center of the array

with the greatest correlation with the initial array at time t2 is the end point of the echo moving vector.

Find the corresponding moving vector for all initial arrays at t1, and divide the obtained vector field by the time interval Δ t. The TREC velocity vector field (hereinafter referred to as TREC vector field) is obtained. This section first evaluates the difference between the total rainfall estimated by radar and the surface rainfall stations during the period from July 2014 to September 2015. The specific method is to calculate the ratio of the total rainfall estimated by the radar to the total rainfall observed by the rainfall station for each station. Because the eight surface rainfall stations are evenly distributed within the radar observation range, the arithmetic average method is directly used to calculate the average value of the total rainfall ratio corresponding to each surface rainfall station. In the simulated uniform wind field with the initial wind speed of 3 m/s, some vortex wind fields are superimposed. These vortex wind fields have both auxiliary wind fields and auxiliary wind fields.

2.2 Urban proximity prediction based on urban microclimate characteristics

A superimposed vortex wind field with a maximum value of 11 m/s and a minimum value of 0.5 m/s. The whirlwind is located in an area with an azimuth of 30 °~70 ° and a radial distance of 8~16 units of length. Figure 6 shows the wind speed of the simulated wind field, and Figure 7 shows the wind direction angle of the simulated wind field. The Doppler radar data since the operation of Taiyuan radar station has been back-checked, and non-precipitation echo samples have been extracted The Doppler velocity image of elevation 5 b is disordered by the interference of ground objects, which will not be considered in this study, and different elevations (1 5 b 、2. 4 b、3. 4 b) When estimating the TREC vector field, the CAPPI reflectivity factor field at each height is divided into 18 km × An initial two-dimensional pixel array of 18 km, with an interval of 5 km between the arrays.

Generally, the moving speed of precipitation echo is less than 100 km/h. In this paper, the maximum search radius is 10 km. The moving wind vector of the echo is obtained by cross correlation method for the echo at the front and back two times, and the quality control of this wind vector is carried out using the method given by Yan Hongmei et al. (2008).

The inverted wind speed and direction angle are shown in Figure 8 and Figure 9. Compared with the simulated wind field, it can be seen that the inversion of the uniform wind field is very good. In the vortex area, it can be seen that the inverted wind speed and direction angle have obvious fluctuations. The statistical results show that the stronger the Doppler velocity convergence of the non-precipitation echo is, the more conducive it is to the generation, development and maintenance of the precipitation system, and the more conducive it is to the expansion of the range of the discrete echo around the station to form a large range of precipitation.

3. CONCLUSION

Through data survey and case analysis, this paper deeply and systematically studies the velocity echo characteristics of non-precipitation echo and points out that the Doppler velocity characteristics of non-precipitation echo are closely related to whether the precipitation echo moves to the local station or not, and the generation, development, maintenance and dissipation of precipitation system, and have a certain forecast advance. The experiment conducted in this paper uses ideal simulation data, there is still a certain gap with the real Doppler lidar data. The data measured by time lidar is not uniformly distributed. In the follow-up work, the algorithm can be improved according to the actual radar data mode.

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