The Use of Dual-Doppler Radar Data in the Study of 1998 Meiyu Frontal Precipitation in Huaihe River Basin

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ABSTRACT

During the Meiyu period in June and July of 1998, intensified field observations have been carried out for the project "Huaihe River Basin Energy and Water Cycle Experiment (HUBEX)". For studying Meiyu front and its precipitation in Huaihe River basin, the present paper has performed analysis on the middle and lower level wind fields in the troposphere by using the radar data obtained from the two Doppler radars located at Fengtai district and Shouxian County.

From June 29 to July 3 in 1998, the continuous heavy precipitation occurred in Huaihe River basin around Meiyu front. The precipitation process on July 2 occurred within the observation range of the two Doppler radar in Fengtai district and Shouxian County. The maximum rainfall of the Meiyu front was over 100 mm in 24 h, so it can be regarded as a typical mesoscale heavy precipitation process related to Meiyu front.

Based on the wind field retrieved from the dual Doppler radar, we find that there are meso-γ scale vertical circulations in the vertical cross-section perpendicular to Meiyu front, the strong upward motion of which corresponds to the position of the heavy rainfall area. Furthermore, other results obtained by this study are identical with the results by analyzing the conventional synoptic data years ago. For example: in the vicinity of 3 km level height ahead of Meiyu front there exists a southwest low-level jet; the rainstorm caused by Meiyu front mainly occurs at the left side of the southwest low-level jet; and the Meiyu front causes the intensification of the low-level convergence in front of it.

Key words: Dual Doppler radar, Meiyu front, Meso-γ scale vertical circulation

1. Introduction

Studies on Meiyu front in the 1970s already have shown that rainstorm and strong convective weather directly related to mesoscale system, and the synoptic scale vertical circulation structure of Meiyu front has been demonstrated (Tao et al., 1979). In addition, there is a large water vapor gradient and a weak wind field convergence zone around the Meiyu front. Meiyu frontal precipitation is often accompanied by the southwest low-level jet, the
rainstorm caused by Meiyu front mainly occurs at the left side of the low jet (Zhu et al., 1992). In heavy rainfall cases, Meiyu front can cause precipitation of 100–300 mm a day. In recent years, the cloud clusters, its mesoscale features and precipitation during Meiyu period are studied with the satellite cloud imagery. Now, the internal flow field features of these cloud clusters can be revealed by Doppler radar data.

Many studies have been done previously on Meiyu front precipitation. For example, the significance of lower level jet on heavy precipitation was analyzed in terms of synoptic scale. Matsumoto (1972) studied the dynamic mechanism of the lower level jet; Akiyama (1973) and Zhai, et al. (1999) studied the relationship between the low level jet and heavy precipitation. During the Meiyu period, the low level jet can transport the warm and wet air from the Bay of Bengal to Huaihe River basin and provides the water vapor that heavy precipitation requires. Ninomiya and Akiyama (1992) noted that the interaction of multi-system of various scales plays a very important role in Meiyu precipitation. They made analysis by using surface rainfall data and the satellite cloud imagery data and indicated that the heavy precipitation process in Meiyu front was mainly caused by the meso-α scale precipitation system. Zhu et al. (1994) studied the meso-scale structure of rainstorm in Meiyu front and demonstrated that the lower level cold advection and the surface meso-scale convergence are favorable to the development of rainstorms.

In the past, little has been done on the meso-β and -γ scale analysis of Meiyu front precipitation because of the limitation of observation facilities. With the development of Doppler radar detecting technology, quite a number of achievements have been obtained as regard to meso scale analysis with Doppler radar data. Ogura et al. (1985) pointed out that convective scale analysis is of great significance to the study of the merging of cloud cluster. They also indicate that the low level convergence in Meiyu period plays an important role in the development of rainstorms. Hot et al. (1998) made a study on the inner air flow structure of Meiyu front in “Taiwan Area Mesoscale Experiment (TAMEX)” by using the airborne radar and demonstrated that the Meiyu front has the characteristics of weak disturbance, low level cold center, etc.

As an effective detecting tool, Doppler radar is able to identify clearly the meso-β and -γ scale structure that cannot be solved with the conventional weather radar. For example, with the dual Doppler radar, Zhou (1990) made an analysis of the cross-section structure of the across front convection area in one of the Meiyu fronts in “Taiwan Area Mesoscale Experiment (TAMEX)” and found that there existed a strong convergence in the lower layer of troposphere in front of the Meiyu front. Takahashi et al. (1996) analyzed the features of the mesoscale and convective scale of the Meiyu front precipitation in Japan Island with the Doppler radar. They pointed out that the convection gust front leads to the intensification of lower level convergence. In the Huaihe River basin of China, there were no dual Doppler radar data available before the project HUBEX in 1998. Taking the features of the observational area of the two Doppler radar into consideration respectively in Fengtai district and Shouxian County, the present paper mainly analyzed the wind field structure of the lower and middle layers in the Meiyu front during heavy rainfall period on July 2, 1998 with the dual Doppler radar data, in order to study the inner wind field structure and its development in the Meiyu front precipitation process.

2. Data and method

In June and July of 1998, three Doppler radars from Japan that were arranged in the