P3B.3 THE NOWCASTING OF LIGHTNING IN BEIJING REGION

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1. INTRODUCTION

According to the classification by WMO (World Meteorological Organization), lightning is one of the most 10 serious nature disasters. Statistical data show that lightening caused disasters annually bring us huge losses. Beijing is one of the regions where lighting disasters happen frequently costing more than one million dollars every year.

Many researches are focused on this field. Michimoto (1991), Gamer et al (1997), Oram (1999), Zajac and Weaver (2002) provided the relationship of reflectivity in special temperature and lightning occurrence for the purpose of the short-term forecasts and the nowcasting. Garner (2002) described the condition of lightning forecast of the NWS Spaceflight Meteorology Group for supporting the Space Shuttle and Space Station operations.

This paper describes a lighting research project, sponsored by Beijing Sciences and Technology Committee, which aims at providing an advanced capability for monitoring and nowcasting lightning

2. SYSTEM CONFIGURATION AND OPERATION

2.1 History of lightning monitoring in Beijing

In 1988, the first monitoring network of surface/earth lightning was built in Beijing for academic research, which was regarded as the beginning of a series of systematic research on climate features of lightning. Since then, comparative analyses have been conducted to explore the relationship between lightning and radar echoes in severe mesoscale convective system(Qie et al,1993). The research have also been focused on developing a spatial distribution method of accurately estimating the efficiency of lightning detecting for the construction of the network of lightning detecting and monitoring (Tao and Meng,1996).

In 1999, the network was used as a regular tool in business. The research on lightning forecasting was conducted. The forecasting methodology of PSU/NCAR mesoscale model (MM5) is used to combine the criteria of forecasting potential thunderstorm and the physical weighting coefficient to form a single integrated parameter. Based on this approach, a 12-24 hr lightning potential forecast capability has been developed.

In 2002, a two hour automatic lightning nowcasting system based on Doppler weather radar was successfully built. This system covered Beijing and the surrounding area.

2.2 Configuration of lightning monitoring and nowcasting system (LMNS)

With the dramatic development of technology, open and modularized design has been used in system construction. Therefore, the system is easy to adapt the latest technology, and flexible to update. According to the requirement of different functions, the LMNS system includes two modules, lightning detection and nowcasting.

2.2.1 Data source

Data was collected from the lightning network, Doppler weather radar, and radiosounding. Lightning network was formed by 4-station pattern. All the sensors XDD03A, made in Xinxiang the 22nd Institute of Electronics, used magnetic direction finding (MDF) and time of arrival (TOA) as the criteria, which could cover the most area of He Bei province and Beijing (500km). So, all the cloud-to-ground lightning in this area could be theoretically detected. (Note that, in this paper, lightning means cloud-to-ground lightning.) Figure 1 showed the distribution of nodes in the network. The central station is Beijing Meteorological Observatory.

CINRAD/CC(C Band) weather radar is the new generation fully coherent Doppler weather radar. It is used in LMNS for a completed real time volume scan to detect and monitor lightning within the area of 150 km, The information of a thunderstorm life cycle is main data input to lightning nowcasting algorithm. The time interval of CINARD/CC volume scan is 15 minutes.

In addition, lightning and radar data are integrated

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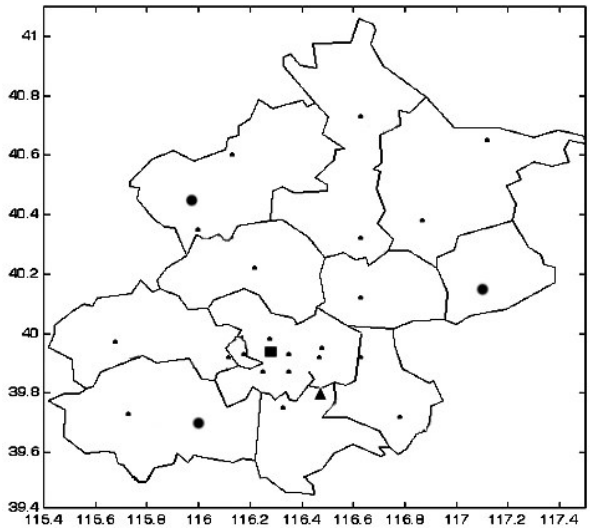

Figure 1. Map of Beijing region and the distribution of XDD03A stations in the network of lightning location. ●XDD03A ■Radar(and XDD03A) ▲radiosounding • weather station

and displayed together to provide images of lightning development process. To some degree, radar signal can also be used as an indirect detecting indicator.

In general, radiosonde is used to measure stability of atmosphere. In LMNS system, the twice-a-day radiosounding (0000UTC, and 1200UTC) is used to obtain the heights of specific temperature layers in frozen region, such as -5℃, -10℃, -15℃, -20℃, and so on.

2.2.2 Method and results

The concept of neural networks was developed in 1960's and has been widely used in pattern recognition recently. For the purpose of the nowcasting, the pattern recognition technique can also be used in processing the lightning data.

LMNS aims at recognizing lightning in the thunderstorm. The supervised recognition is based upon an error back-propagation neural network, which contains a hidden layer (BP Network). Its output is needed in LMNS. Its structure is showed in Figure 2.

The network needs following input: altitudes of some specific temperatures (they are 0℃, -5℃, -10℃, -15℃, -20℃ layers); the maximum reflectivity in these temperature levels; the maximum of vertical integrated liquid (VIL) water in thunderstorm; and the lightning frequency 30, 20, and 10 min before the radar scan.

The BP network trained by the data collected in the

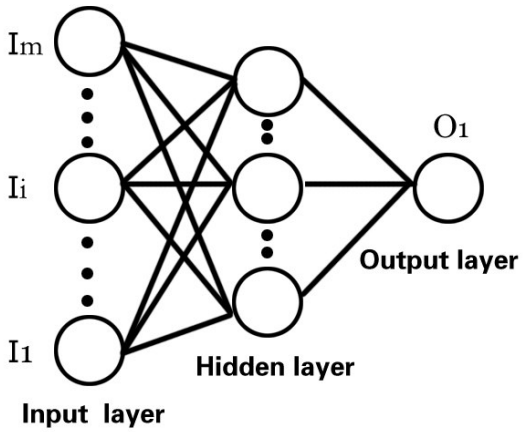

Figure 2. The structure of neural network used in LMNS. I is input factor, O is output which is warning result.

summer, 2001 is used in LMNS. During system running, radar data, radiosounding, and the lightning location information is collected automatically. After the data pre-processing, 35dBZ is used as a reflectivity threshold to detect the edge of thunderstorm. The reflectivity threshold for the edge detection, mark, location, and the extraction of features of characteristic variables is computed automatically by the edge detection algorithm. Combining data from radar, lightning location, and radiosounding, recognition of thunderstorm cloud is recognized and classified by neural network. Then the thunderstorm tracking algorithm is used to obtain the moving vector of radar echoes, and to predict the future location of high frequency lightning area, i.e., warning area for lightning. This area was displayed graphically by isoline at GIS platform.

After the automatic forecasting results is produced, weather forecasters will get a voice reminder of asking them to watch the results displayed on screen, then on the human-computer interactive platform, forecasters will make 0-2 hr lightning forecasting and broadcast a warning message to the public by telephone network.

During the system running in 2002, the performance of LMFS showed that, critical success index(CSI) was 78.4, probability of detections (POD) was 85%, and false alarm rate(FAR) was 9.4%.

3. DISCUSSION AND SUMMARY

The establishment of this system provides an effective tool to improve lightning monitoring and nowcasting capability in Bejing region.

Predicting the onset of lightning activity in the thunderstorm is critically important. Analyses of the nowcasting results of 2002 reveal that the ability of predicting lightning onset is still limited. It is mainly due to some defect in detecting technique for cloud lightning as well as the low observation frequency of the radar at present time.

Because of lack of the prediction ability for the development and decay of a thunderstorm in the algorithm used in the LMNS, a false warning may be produced when the thunderstorm was in decaying state.

This work is a very beneficial effort for the Beijing lightning nowcasting operation. More researches are clearly needed to study the influence of cloud lightning with lightning detecting equipment. For this purpose, CINRAD/CC has been updated to Dual Linear Polarization Doppler Weather Radar; the observation cycle of the radar will be reduced. Furthermore, electric field mill instruments will also be widely used. Therefore, it is likely that the lightning detection and nowcasting ability will be improved in near future.

4. REFERRENCE

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