2014 23rd International Lightning Detection Conference
18 - 19 March • Tucson, Arizona, USA
5th International Lightning Meteorology Conference
20 - 21 March • Tucson, Arizona, USA

Research on Experiment of Lightning Nowcasting and Warning System in Electric Power Department of HeNan

Ning Zhou[1)] 周宁 Zhe LI[1)] 李哲 Wen YAO [2)] 姚雯 Qing MENG[2)] 孟青

1) State Grid Henan Electric Power Research Institute, Zhengzhou 450052, China

2) State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences, Beijing 100081

ABSTRACT

Many facts show that no matter direct lightning or lightning induction, which can cause great impact on power equipment. If lightning hits the circuit, the current will along the wire into the equipment, it may cause the damage. And indirect damage will be induced by lightning induction, because the lightning invasion without channel limits, which caused more damage. In order to ensure the safe operation of transmission lines, Henan Electric power company Electric Power Research Institute and Chinese Academy of Meteorological Sciences developed a Lightning Nowcasting and Warning System (HAEPC_CAMS_LNWS), which integrating multiple observation data, multiple parameters and multiple algorithms. Many observation data are used, such as radar, satellite, lightning monitoring system, surface electrical field mill, sounding data, etc.. Through the study of the multiple observation data, the lightning frequency; Echo Intensity and its Variability Rate; Echo Tops of radar et. al. as the main parameters used in the system and two basic algorithms are implemented: one is area identification, tracking and extrapolating algorithm, and the other is decision tree algorithm, both of which are successfully applied in some warning modules. During summer time of 2013, Operational experiment about HAEPC_CAMS_LNWS run all around Henan power company, which could realize 0-1 hours , 1 × 1 km radius of lightning nowcasting, and provide rapid response to meteorological information for the electric power.

The experiment results showed that HAEPC_CAMS_LNWS may runs steadily and enables its product sharing by internet. It showed that HAEPC_CAMS_LNWS had favorable forecasting ability for regional

lightning activity, which will provide lightning service information of high-quality, high spatial and temporal resolution for power company.

Keywords: Lightning, Electric power, Nowcasting and Warning, Experiment

1. INTRODUCTION

The Lightning Nowcasting and Warning System (HAEPC_CAMS_LNWS) was developed by State Grid Electric Power Research Institute and Chinese Academy of Meteorological Sciences. In view of strong convection weather in the local areas, the system proposed a lightning characteristic diagnose and nowcasting scheme in typical region, and mainly adopted radar and lightning monitor data, its foundation is the analysis of lightning space-time distribution characteristics and radar echo characteristics of thunderstorm monomer in local region. The HAEPC_CAMS_LNWS system was designed in framework and modularization, which can provide convenient for the continuous upgrading and improving of nowcasting and warning method in the future. The methods were based on algorithm of area identification, tracking and extrapolating algorithm and decision trees algorithm. The HAEPC_CAMS_LNWS system runs by every 6 minute interval, the same as the radar time, and supplies products of Lightning Occurrence Probability, which can be applied and promoted to a variety of occasions and areas, especially to respond rapidly for state grid and protect the transmission line. And it also has the product of lightning occurrence probability of key area. We can set the area of interest arbitrarily, when the system detected the lightning occurrence probability reach the specified level, it can alert corresponding.

It is easy to implement applications of HAEPC_CAMS_LNWS as a result of its friendly man-machine interfaces and rich controls parameters. And it can run without manual intervention in automatic mode.

1.1 Design Scheme

The quasi-real-time and real-time observation data of the fine spatial and temporal resolution, such as lightning data and radar data, were considered in the design scheme. Because the real-time observation data of ground electric field instrument were related to the lightning activity directly, the records of ground electric field were also important reference for lightning nowcasting and warning. The design diagram was shown in Figure 1.

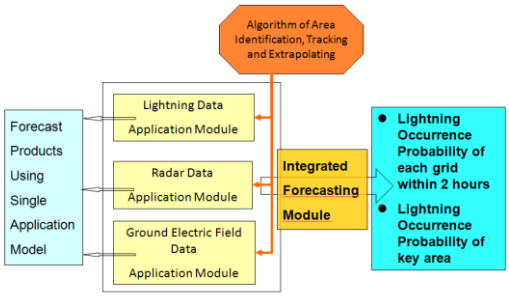

Fig.1 The design diagram of HAEPC_CAMS_LNWS

As Fig.1 showed, each application was using separate modules, like application module of lightning data, radar data and ground electric field data and one integrated forecasting module in this system. This was not only easy to implement calls between different modules, but also facilitate to improve the method in the future.

The method of Area Identification, Tracking and Extrapolating Arithmetic(AITEA), was used for lightning, radar data application modules and integrated forecasting module, which could identify regional areas of the lightning occurred and may occur and the use of multiple observations of several intervals to keep track of these areas and extrapolation to predict probability of lightning occurrence.

1.2 system process

In HAEPC_CAMS_LNWS, Users can set warning area, grid resolution; application data participated and the weight of each data and it also can set the parameters of validity reprocessing period and the warning step parameters. First, system can preprocess corresponding data according to the user's settings, then use a single application module one by one and finally integrate the nowcasting and warning products.

Data preprocessing was to ensure the effective operation. Each valid data file was gridded-processing according to the parameters set by the users, and the interpolation method adopt bilinear interpolation method. As for real-time lightning monitoring data, it should specify the time step, which could preprocess to generate multiple periods gridded data, the data of each grid point was the number of lightning frequency within the time interval.

1.3 Algorithm introduction

The method of Area Identification, Tracking and Extrapolating Arithmetic (AITEA) was the main algorithm in this system, which referred on the TITAN developed by the NCAR, Munkres' Assignment Algorithm Modified for Rectangular Matrices (Hungarian) and Holt two-parameter linear exponential smoothing method.

In order to adopt a uniform AITEA by different application modules , AITEA used a common interface, various kind of data obtained after a gridded-processing, should be handled through the binarization processing (the value of matching grid is 1, 0 otherwise),then it can use AITEA to realize identification , tracking and extrapolating. AITEA will not be descripted in detail.

Each application data has its advantages and disadvantages for lightning nowcasting and warning. Lightning monitoring data in real time is

very good, but the warning ahead of time is limit. Ground electric field data in real time is also very effective, but the warning area of single station is limit, and the warning time is also limit for closer thunderstorms. Radar data has good space and time resolution, but the stronger echo will occur only after the precipitation particles, so the early warning time is also limit. So the multiple application data should be used together, which can improve the accuracy of lightning nowcasting and warning. In HAEPC_CAMS_LNWS, multiple application data combination forecasting method was adopt, The prediction results of multiple application module used the specified weights to get the final forecasting results through weighted average.

2 OPERATIONAL EXPERIMENTS

In the summer of 2013，the HAEPC _CAMS_LNWS has been promoted for operational use in State Grid of Henan. Additionally, it played a very important role in lightning forecasting service from May to September. In Henan, strong convections happened frequently during summer. In order to respond to the lightning strokes on transmission lines and power station facilities, the HAEPC_CAMS_LNWS worked 24 hours every day and renewed the warning products every 6 minutes automatically. Warning products were published on the integrated display platform, and Decision makers take measurements timely.

August 1st, 2013 from afternoon to night, it was a meso-β scale thunderstorm weather system. According to the monitoring system of CG lightning, lightning activity moved from southwest to northeast obviously. (Figure.2)

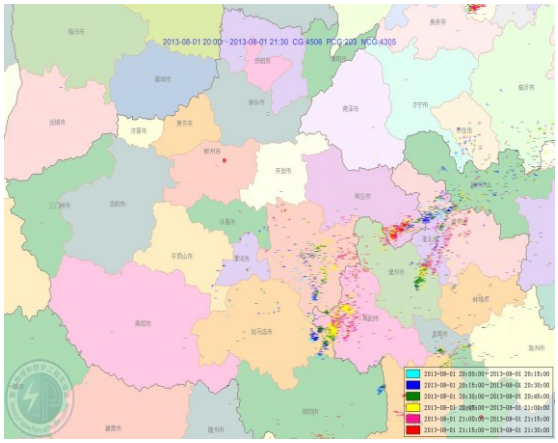

Fig.2 The distribution image of the temporal variation of lightning in Henan on August 1st, 2013.

The HAEPC_CAMS_LNWS gives the lightning occurrence probability results of 20:48~21:03 at 20:48. Figure.3 provides the images of every 15 min from 20:48 to 21:18. The results suggest that, the HAEPC_CAMS_LNWS system has a good relationship on spatial-temporal variation by comparing lightning observation data with forecast result.

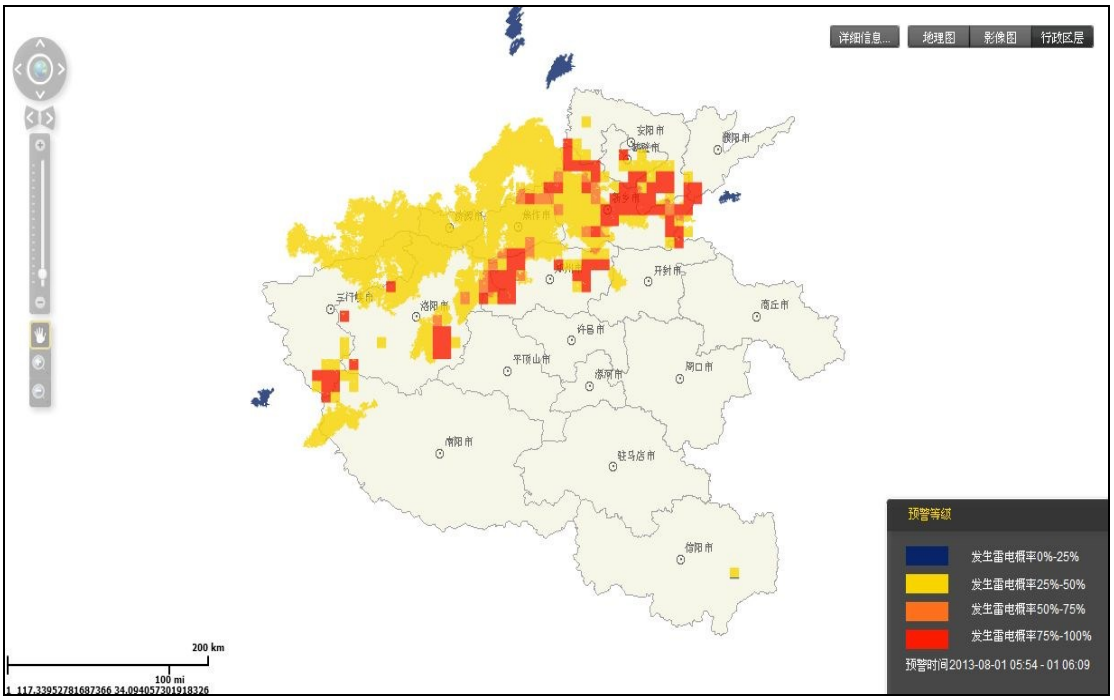

Fig.3 Lightning occurrence probability products given by the HAEPC_CAMS_LNWS for 05:54~06:09 on 1st August 2013.

3 DISCUSSIONS AND CONCLUSION

Through evaluating many thunderstorm processes in 2013 at Henan, the results show: POD of 15min exceeds 50%, TS up to 0.19, POD of 45~60min up to 27%. The HAEPC_CAMS_LNWS had a good forecasting and warning ability for lightning activities in local and its vicinal area. The HAEPC_CAMS_LNWS works steadily and provides variety of products. It can read multi-source detection data on time, yield warning products automatically.

When lightning activity regions are complex, the HAEPC_CAMS_LNWS has worse forecasting results compared to simple lightning activities. Because the forecasting method is based on region recognize, tracking and extrapolation.

Operational experiments of the HAEPC_CAMS_LNWS are still in progress now. In the future, we will carry out in-depth studies to reveal the evolution characteristics of lightning activity, A 0~6 hour numerical forecasting method for lightning activity will be developed in order to improve lightning forecasting effect and progress the national lightning detection, forecasting and warning service ability to a new level.

ACKNOWLEDGMENT

This work is supported by Strong convective weather systems and the development of meteorological disaster monitor warning project.

REFERENCES

Bridenstine P., C. Darden, J. Burks, S. J. Goodman: The Application of Total LightningData in the Warning Decision Making Process. Conference on the MeteorologicalApplications of Lightning

Data, San Diego, CA, January 2005.

Dixon, Mlig., and G. Wiener. TITAN: Thunderstorm Identification, Tracking, Analysis, and Nowcasting—A Radar-based Methodology. Journal of Atmospheric and Oceanic Technology, 1993, 10: 785~797.

Feng Guili, Qie Xiushu, Zhou Yunjun. A Case Study on Characteristics of Lightning Activity in a Mesoscale Convective System. Plateau Meteorology, 2006,(2).

Gatlin, P. N., and S. J. Goodman, 2010: A total lightning trending algorithm to identify severe thunderstorms. J. Atmos. Oceanic Technol., 27, 3–22.

Goodman, S.J., Predicting thunderstorm evolution using ground based lightning detection networks, NASA Tech. Memo, TM-10352, 210 pp., 1990.

Ma Ming. A study of the relationship between lightning activity and climatic variation. Ph.D. Thesis, University of Science and Technology of China,2004

Meng Qing, Lu Weitao, Yao Wen, et al. Application of Detection Data from Electric Field Meter on Ground to Lightning Warning Technique. Meteorological Monthly, 2005，31(9): 30~33.

Qie X.S., Guo C.M., Yan M.H. and Zhang G.S., 1993, Lightning data and study of thunderstorm nowcasting, ACTA Meteorologica Sinica, 7(2): 244-256.

Wang Fei, Zhang Yijun, Zhao Junzhuang, et al. The Prelimiary Application of Radar Data to the Lightning Warning of Isolated Storm Cells. , Journal of Applied Meteorological Science, 2008， 19(2): 153~160.

Xu Xiaofeng. Lightning Induced Disasters and Its Detecting and Forecasting. Meteorological Monthly, 2004, 30(12): 17~21.

Zheng Dong, Zhang Yijun, Lu Weitao, et al. Atmospheric Instablity Parameters and Forecasting of Ligthning Activity. Plateau Meteorology, 2005，24(2): 198~203.