Research on Lightning Warning with SAFIR Lightning Observation and Meteorological detection Data in Beijing-Hebei Areas

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ABSTRACT

A field experiment with SAFIR system during summer seasons in 2003-2004 is organized by China Meteorological Administration. Meanwhile we will put up the research on method of lightning warning for severe weather through lightning observation with SAFIR system.

The correlation coefficient with time sequence of radar echo data, the distribution map of lightning discharges and the typical lightning characteristics have been analyzed based on the data detected by SAFIR 3000 system, the pattern of meteorological radar echo, and other parameter changes in meteorological detection data from a few strong thunderstorm. The results indicate that good correlation between radar echo data and SAFIR 3000 location distribution, SAFIR 3000 system own the capability of lightning warning with the moving trace of thunderstorm cell and detection three dimension distribution of lightning discharge. It is also shown that SAFIR 3000 location data is important parameters of lightning warning and study on the method of severe weather forecasting, lightning protection and weather modification etc.

Keywords: Lightning warning, SAFIR3000, Radar echo

1. Introduction

In order to meet the need of the development for automatization of atmospheric detection and sensing, standardize the establishment of operational National Lightning Detection Netwotk (NLDN) and expand its applications on disastrous weather forecasting, lightning protection and weather modification etc., China Meteorological Administration (CMA) organize the field experiment with SAFIR 3000 lightning detection system in different experimental areas in China.

The field experiment with SAFIR system formally started from June 23, 2003 to Oct 1, 2004 in Beijing-Hebei areas. The localization principles of SAFIR network are based on the VHF interferometric technique[1]-[2].The Long rang localization of all lightning discharges (CG and CC lightning flashes) is obtained by triangulation performed on GPS time synchronized direction of arrival provided by interferometric sensor of two different detection station in a SAFIR network. In Beijing-Hebei area spot, three interferometric antennas were installed at Huairou in Beijing suburb , Fengrun and Yongqing in Hebei area via survey and selection.

The strong convection, precipitation and lightning activities are often produced in thunderstorms. A lot of significant research results on the relationship among them have been revealed with the applications of lightning location system. There are a significant relationship between severe weathers such as hail, heavy precipitation and tornado, which often occur in supercell thunderstorms, and temporal and spatial characteristics of lightning discharges [3-4].

In this paper, the observed data of strong thunderstorms are analyzed and typical lightning characteristics at beginning, mature and dissipation stage of thunderstorm and the relationship between lightning and convection are discussed.

2.　Observation and analysis

Figure1 shows the operational coverage of SAFIR 3000. Three sites places respectively situate at Huairou, Fengrun, and Yongring Meteorological station. The city zone of Beijing almost nears the center of detection areas.

Nowadays the SAFIR network have operated and observed several thunderstorms in the filed experiment. More than 200 days lightning location data，echo pattern data of Doppler weather radar and the normal meteorological detection data in 2003-2004 summer season are obtained.

Figure2 shown an example of severe weather passed over the edge Beijing region on June 23,2004. From Figure2(a) and (b), it is seen that Beijing-Heibei areas are located in the trough region. There are two Radar echo which had strongest intensity echo of more than 45dBz during 07:41-08:23, the northwest one moved down to south and the southwest one moved up to north. From Figure2(c) and (d), it is also noticed that lightning discharges location record are associated with storms distribution along southwest-northwest frontal disturbance which the two independency cells moved separately toward north and south with time. Figure2(e) and (f) shown the general trend in variation of lightning flashes rate with the peak of flashes rate of about 30/min during 08:00 to 09:00 (UTC). Compared with Figure2(a)-(f), activity of lightning sources is associated with the radar echo on temporal and spatial characteristics in strong

storm updraft region. According the meteorological observation, it appeared hailstone caused by the northwest echo which created strong echo center with 90 km^2 areas at YanQing in north of Beijing. At the meanwhile, there are a lot intro-cloud lightning discharges location detection by SAFIR 3000 at YanQing (figure2(d)). After 08:40(UTC), intro-cloud lightning discharges decreased dissipation stage of thunderstorm. These lightning discharge sources are a good indicator for variation of strong convection at the beginning, mature and dissipation stage of thunderstorm.

Figure 3 shows another example of location which were recorded on September 23, 2003. SAFIR 3000 system may gave us warning of thunderstorm activity almost 30 minutes advance. Figure 3(a) and (b) shows Lightning warning of moving trace of thunderstorm cell for 10 minutes and 30 minutes advance at 22:59. It clearly indicates SAFIR 3000 may provide the information of lightning warning on the spatial and temporal development of thunderstorm.

Figure 3(c) and (d) shows the comparison between lightning discharges and radar echo. The thunderstorm had a band echo that started to develop in the southwest and moved to the northeast of the observation area from 20:00(UTC) to 0:30(UTC) on September 24, 2003, lasting for about 5 hours. The storm produced more than 8,000 lightning radiation events for 4hours.It was seen the lightning data (pink dots) superimposition on a radar echo map at 21:56 and 23:38 (UTC) on September 23th. To get each superimposition map, Radar echo is overlapped with lightning data by forward 10 minute of time radar observation. Form Figure3(c) and (d), it can be observed that there are several storm cells in the band echo, which had strongest intensity echo over 45dBz. Compare with (a)-(b) and (c)-(d), it is believed that the echo may corresponded lightning data during respective time period and SAFIR network may be meet the basic needs of lightning monitor and warning in Beijing region.

The figure3(e) and (f) shows this thunderstorm with lightning discharges locations on temporal and spatial characteristics from 21:00 (UTC) to 23:59. In figure3(f), lightning discharges lightning location are presented by different colors to shows the movement of lightning activity on a 3D distribution map. From figure3(f), it was seen that lightning radiation sources started(blue), at about 21:30(UTC), moving to northeastward, distributed vertically at two altitude of 5-10km and 10-15km. Comparing Figure3(e) and (f), at maturity period, the height of lightning discharges became more and more low with the development of storm. At last some lightning radiation events distributed vertically under 5km. The figure2(f) also present most of lightning radiation sources appeared at 9-10km. The movement of storm shows variation of structure on electric charge and lightning characteristics.

3.Ligntning Warning

Through compare and analysis of the distribution map of lightning discharges detected by SAFIR, the pattern of meteorological radar echo, and the parameter changes in meteorological detection data from thunderstorm, we find the important parameters of lightning warning and study on the method of model and arithmetic for lightning warning.

Figure4 shows the method and steps of lightning warning. The process of lightning warning consist 3 steps, which represented by the red circle .

Setp1：Data collection and analysis. This part is the base of lightning warning, it includes new data detection, as electric field on the ground [5], sounding, satellite and other lightning location data and the data analysis for the use of research on lightning warning, as draw lightning characteristic, calculation the statistic data etc.

Setp2: Lightning warning methods. This key part includes getting the characteristic synthesize diagnosis arithmetic through parameter recovering base on the numerical forecasting analysis products, in order to get the lightning warning product.

Step3: Data display interface. This last step is necessary for user. The software may own two basic functions. One is for represent the lightning warning product, as the moving trace, occurring probability and danger scale of lightning activity. Another is the tool for meteorological detection data analysis on lightning data application. All warning and display product will be sent to any user terminal.

4.Discussions and Conclusion

Based on the observation data analyzed above, we may get the relation between thunderstorm and lightning radiation:

(1)   SAFIR 3000 system can locate the lightning discharge including CG and IC lightning which distribute on 3-dimensional in high temporal and spatial resolution for thunderstorms   and provide lightning warning of moving trace of thunderstorm cell almost 30 minutes advance.

(2)   With comparison of relationship between radar echo and variation of lightning characteristics during summer 2003-2004 in Beijing-Hebei, The lightning radiation sources normally appeared at 9-10km and its vertical altitude normally changes from 10-15km to less 5km with the development of thunderstorms, typical lightning characteristics in the characteristics of lightning were associated with the charges structure in thunderstorm. Lightning discharge sources are a good indicator for variation of strong convection.

(3)   Further study of lightning warning has been improvement in Project on lightning detection, warning and forecasting for Beijing 2008's Olympic Games base on the other new data detection and SAFIR

3000 undergoing performance evaluation [6]-[7] at Beijing--Hebei in 2005 summer season.

The lightning parameter is one of important factors in warning and forecasting severe weathers. Especially, the results are of general significance and can be referred in morning and forecasting severe weathers. However, further researches and observations are needed.

Acknowledgment

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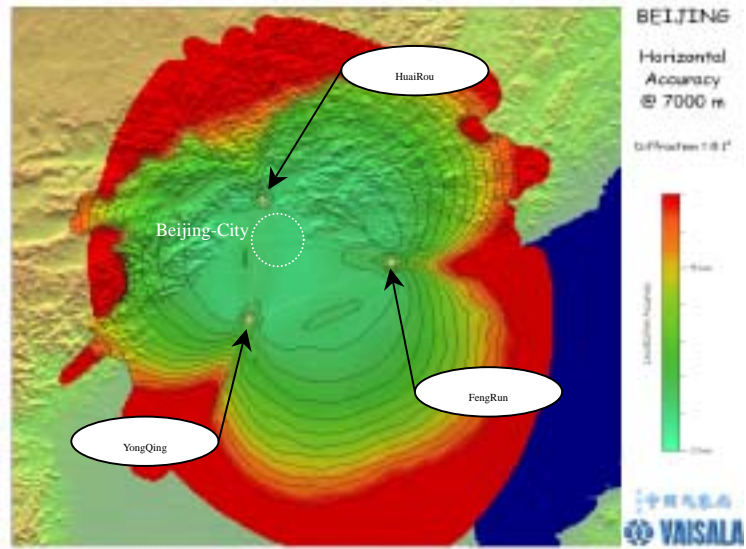
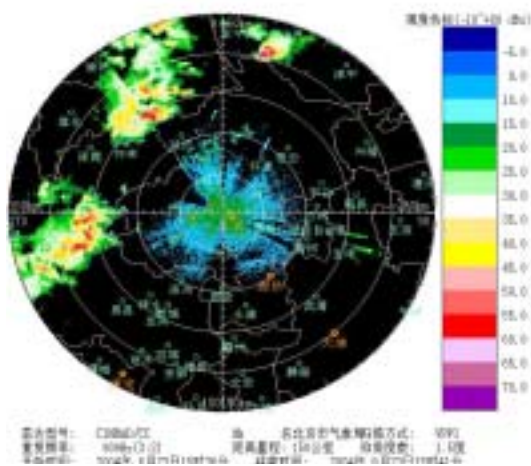**Figure 1:Operational coverage of SAFIR system in Beijing**
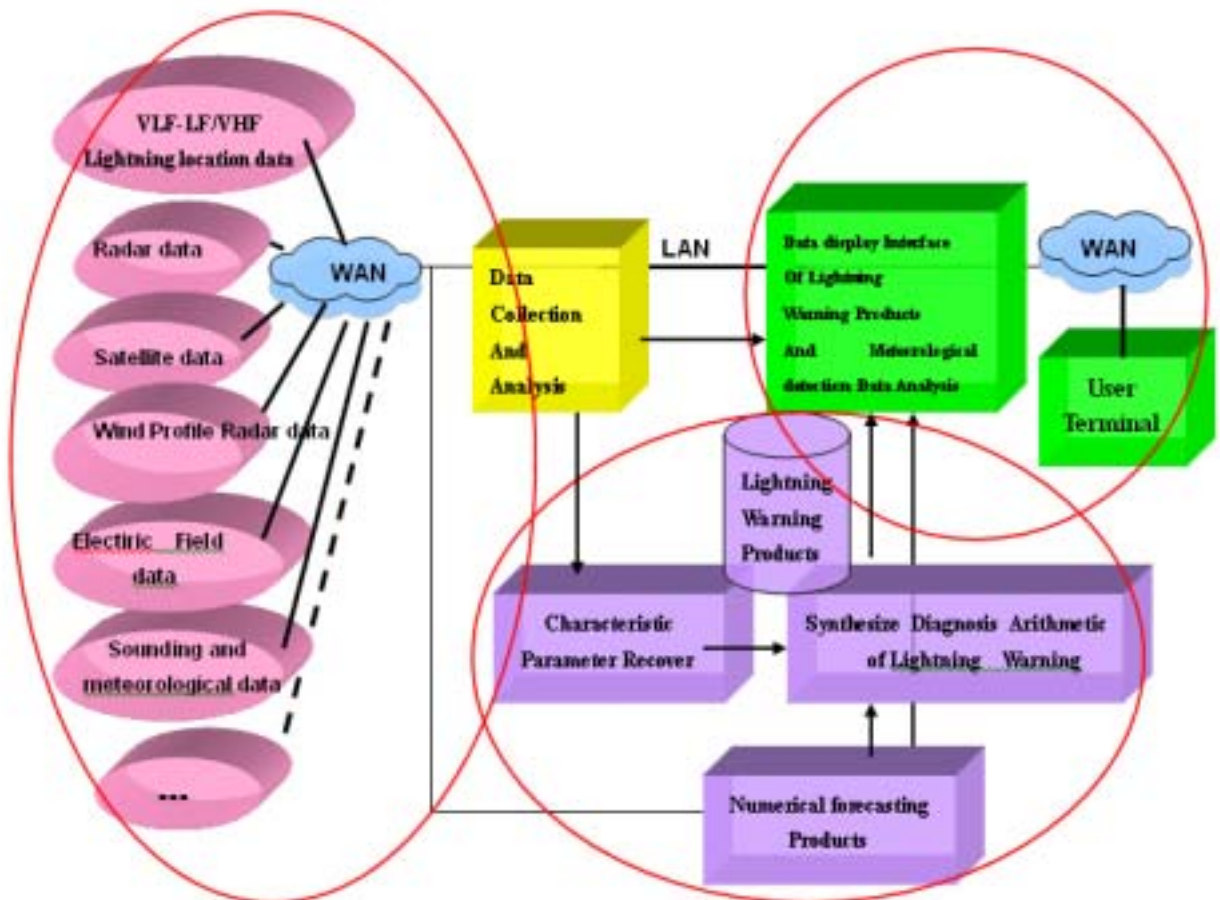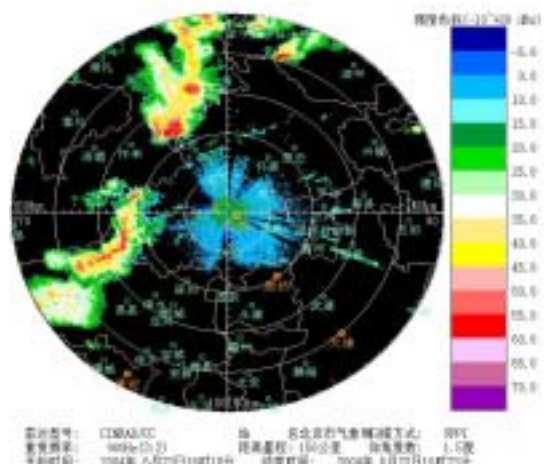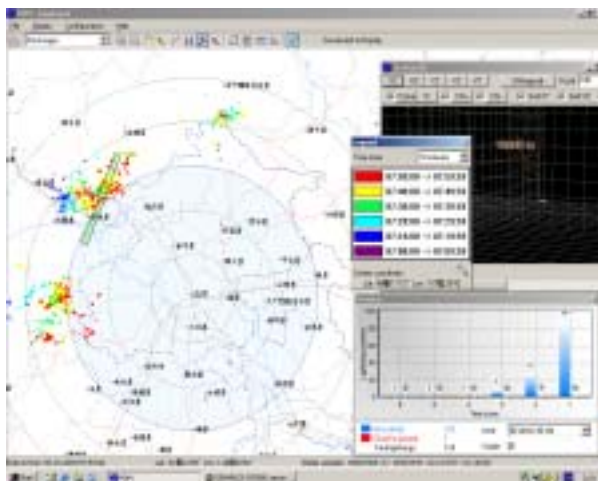

Fig4.   Sketch map of lightning warning method and steps
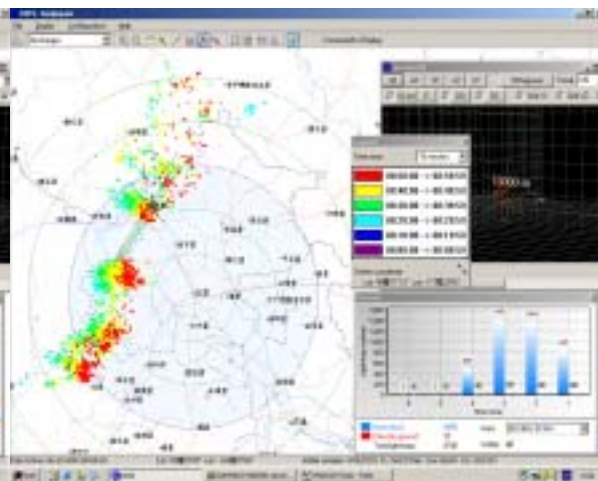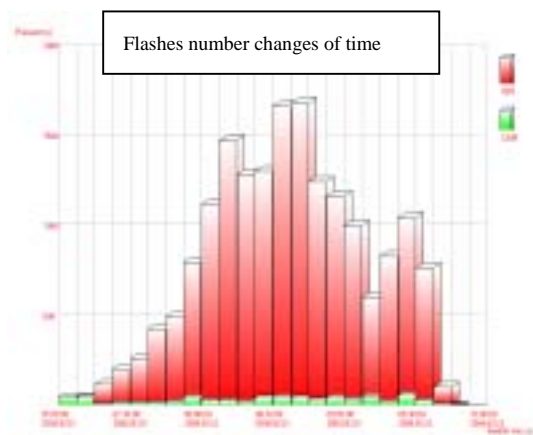
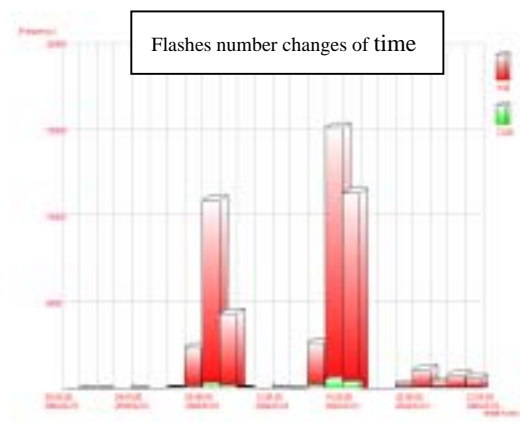(a) Radar data at 07:41(UTC)

(b) Radar data at 08:23(UTC)

(c) Lightning discharge data at 07:00-08:00(UTC)

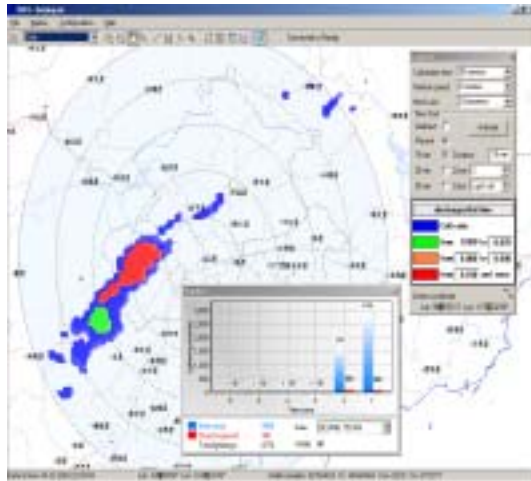(d) Lightning discharge data at 08:00-09:00(UTC)
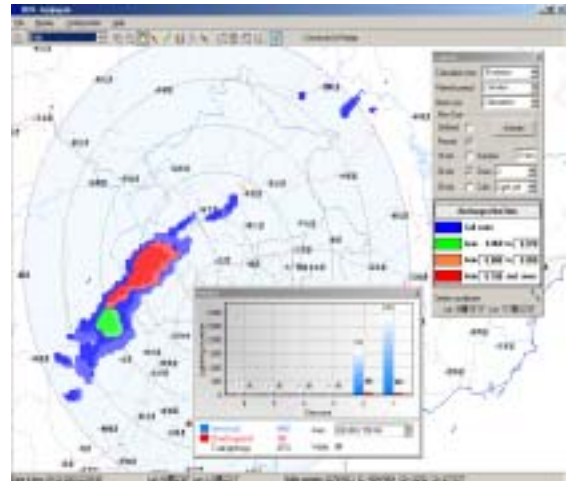
(e)Flashes number changes at 07:00-10:00(UTC)

(f)Flashes number changes on daily

Figure 2:Observation data sample. Meteorological Radar data , Locations of lightning discharges and Flashes number

changes of time detected by SAFIR 3000 network from 07:00 to 09:00 (UTC) on June 23[tha] in Beijing
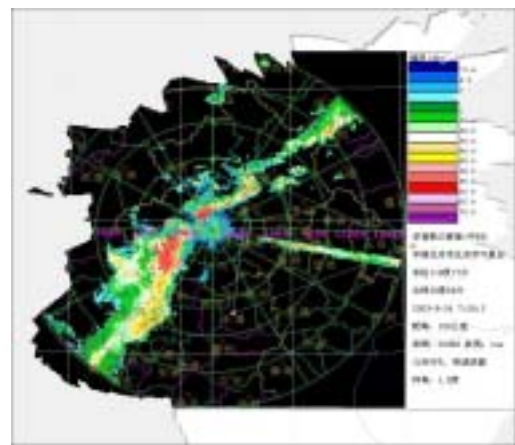
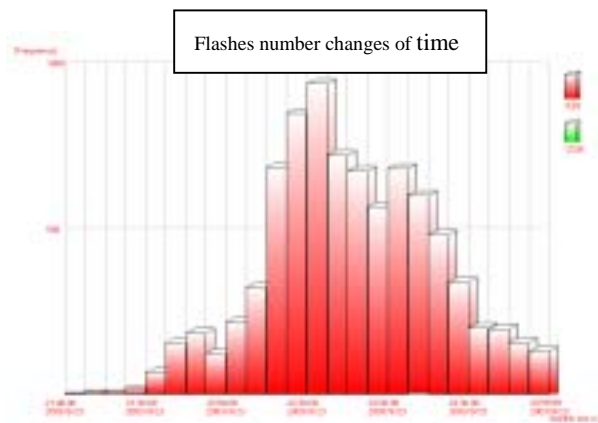(a) Lightning warning 10 minutes in advance   (b) Lightning warning 30 minutes in advance
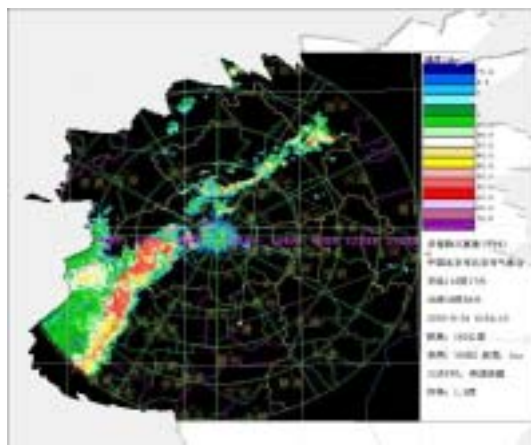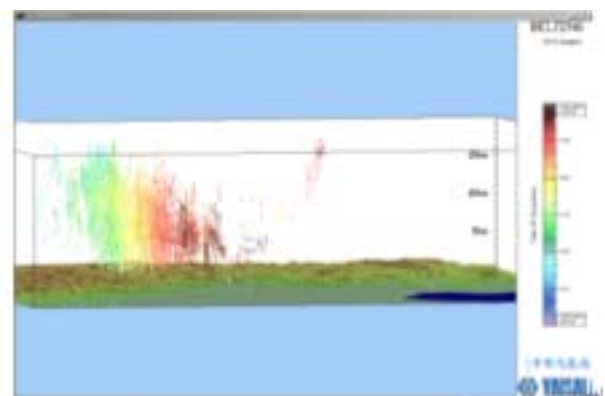

(c) Lightning superimposition on radar at 22:56 (UTC)   (d) Lightning superimposition on rada at 23:38 UTC

(e)Flashes number changes of time   (f) Locations of lightning discharges on 3D spatial

Figure3:   comparison of relationship between of lightning distribution and Radar echo data.(a) and (b) Lightning warning of moving trace of thunderstorm cell Lightning warning 10 minutes and 30 minutes in advance at 22:59 (UTC) estimated by SAFIR 3000 network. (c)   and   (d) Lightning data superimposition on a radar echo map, Lightning data (red dots) are gathered on a 10 minutes time frame centered around radar scan time. (e) and (f), Flashes number changes of time, Locations of lightning discharges on 3D spatial distribution at 21:00-23:59 (UTC) on September 23rd in Beijing.