

First of all, thank you very much for the comments. We have revised some content in manuscript according to the comments. The followings are point-by-point replies to the comments. In order to distinguish, our replies and modifications are used in red text.

Comment1: "From a technical perspective, the detection of lightning mainly depends on the base-line of stations and the threshold to define a lightning event. The analysis of spatial lightning distribution only makes sense when the resolution of detection efficiencies is homogeneous, i.e. the baseline of sensors and threshold are similar. There is no description of how lightning events are detected and extracted and there is no detailed description of the algorithm for the four presented methods. In addition, the distribution of sensors is not homogeneous and some regions are much denser than other areas, and there is also no station in Tibet. I think these missing elements should be included in the discussion."

PS: Thank you for reviewer comments.

Q(1): Indeed, as reviewer say, the analysis of lightning data must be based on the homogeneous of the detection network and detector, i.e. threshold is similar. CMA LDN uses a unified model detector ADTD, to achieve homogeneous of sensor and threshold. Because the network inhomogeneous densities or inhomogeneous distribution of sensors, we use an automatic selection strategy for lightning location algorithms. For example, in the Tibetan Plateau and the surrounding site sparse area, the system can choose the "two station" algorithm, as long as a lightning weak signal can be received by two sensors, the lightning is detected and can be positioned. In the plains, more detectors involved in the detection and location, the system can choose "three station" or "four station" algorithms, which has higher accuracy. According to the lightning detection principle, different baseline may cause the difference in detection efficiency, but the strategy has been reduced the error to a minimum, under realistic conditions, this way is the most practical and reliable.

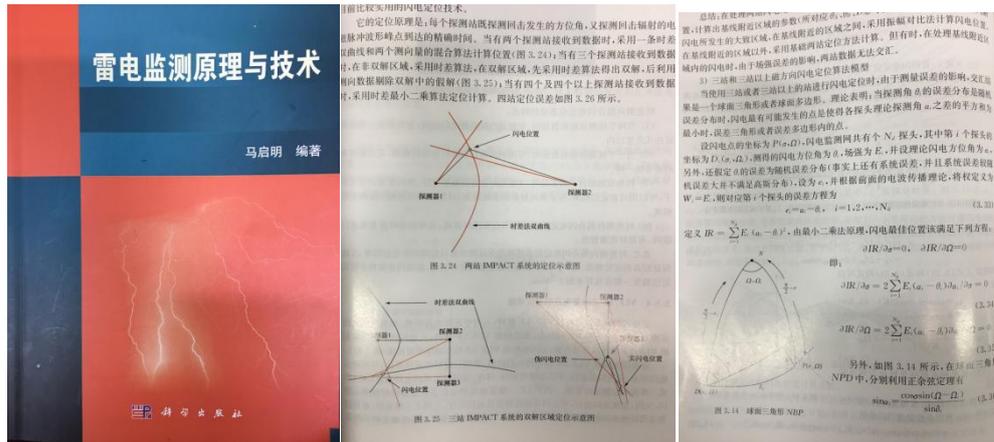
Q (2): This manuscript has introduced CMA LDN distribution and constructor, " 2.2 Lightning Location Method " give lightning location method description, and we add detector ADTD information in introduction section. We think we have described how lightning was detected and extracted. Sorry, we don't know what else need to be added? Whether we need to give the working principle of the lightning detector in this manuscript? We don't think this is the focus of this job.

Q(3): Four lightning location algorithms are introduced in section " 2.2 Lightning Location Method " , and their more detailed description have been published in the literature "principles and techniques of lightning detection (Ma, 2015) ". There are too many content descriptions and formulas about four algorithms, which is not suitable for detailed description in this article. If you are interested, you can refer to the literature (Ma,Q.M 2015). We have added literature information in references part. Below we will provide some reference content, see Figure 1-3).

The main purpose of this paper is to analyze the application of these algorithms in the National Lightning network and the application of lightning data. And to evaluate the improvement of operation capability of lightning network by algorithms usage frequency variation. The algorithm itself is not the focus of this article.

Q(4): These discuss have been added in Summary and Conclusions (line 315-327) and other part

(line 142-143).



(Lightning location and current algorithms reference book and some algorithms extract examples)

Comment 2: The LF and VLF radio signal of CG lightning can propagate over a thousand kilometers or more. The baseline of this network is only 170 km. In my opinion, it should be possible to use more than 4 sensors to determine lightning locations. This reviewer finds it confusing that the authors still use M1, M2 and M4 as they also confirm that using more stations results in better locations in this paper. Further, there is a large section discussing the use of these four methods (Section 2.2), but it is unclear what the scientific meaning of the method 'usage frequency' is. I propose the authors clarify why these methods are used and what the scientific reason of comparing them is.

PS: This is a good question. Reviewer wondered what's purposes and scientific reasons for analysis and comparison of lightning location algorithms 'using frequency' in this manuscripts

As we all know, the quality of the lightning detection network depends on the efficiency and accuracy of the lightning location. However, it is very difficult to confirm the efficiency and accuracy of lightning location. It is generally accepted that both the hybrid method and the multi-station method are better than the two-station method, the magnetic direction method and the amplitude method in the positioning efficiency and accuracy. Furthermore, the more sensors are involved in the localization algorithm, the more accurate the location is. However, by 2013, our multi-station positioning algorithm was most applied to the 4 sensors, and more than 4 sensors have not been applied to the multi-station positioning algorithm. Therefore, the multi-station method mentioned in this paper is the four station method.

Due to the geographical conditions, the number of base stations and network layout, CMA lightning network cannot be all unified use multi-station positioning algorithm. Our strategy is to automatically select the location algorithm in the business software based on the number of detectors detected by one of the lightning signals. From the point of view of spatial distribution, where the higher the frequency of multi-station method is, the more reasonable the base station is, the higher the quality of lightning data. From the point of view of time variation, the higher frequency is selected by the multi-station method, the higher the detection ability of the whole lightning network, and the higher the quality of the lightning data, and vice versa.

The above is the scientific reason and purpose of analyzing and comparing the frequency of using the lightning location algorithm in this paper. This also is a method to evaluate the performance of CMA lightning detection network in this manuscript.

Comment 3: Some results in this paper, such as, that thunderstorms normally occur in the summer and that positive lightning is easier to trigger in winter thunderstorms, were presented before [e.g. Rakov, V. A., and M. A. Uman, 2003, Chapter 2 & 5]. The results in this paper provide a description of the literature but don't present novel results. Overall, I would highly recommend that the authors include further analysis to produce more substantial evidence. For example, the correlation between lightning occurrences and some meteorological and climate information, the spatial distribution of positive lightning, because positive lightning normally occurs close to tall objects or close to objects of moderate height located on mountain tops.

QS: That's a very good suggestion.

Study on Lightning climatology, scholars including China scholars, has done a lot of analysis, including the relationship between lightning and ground temperature, water vapor, aerosol concentration, weather system and geographical conditions, also reveals the characteristics and causes of lightning climate change. According to the suggestion of reviewers, we add analysis on the correlation between China's lightning changes and air temperature, atmospheric troposphere layer height and atmospheric water content, and to reveals the reasons for its abnormal climatology (line 213-233).

According to reviewer suggestions, we analyzed the spatial distribution and changes of positive lightning in winter and summer. Winter (December as a representative, fig.7 right), positive lightning mainly distribute in southern Anhui, northern Jiangxi, North Central Guangxi, Yunnan and Western Xinjiang, these areas are basically mountainous, above 1500 meters above sea level. And summer (especially in June, fig7 left), positive lightning widely distribute in China's central and eastern regions, whether plain or mountain. According to the location of lightning, further statistics (fig7b) shows that winter positive lightning is the most prone to in the 1000-2000 meters height mountains, accounted for 42.4% of total positive lightning, the 50 highest frequency locations average altitude is 1413.5 meters. In summer, positive lightning is most likely to occur at 0-500 meters, accounting for 43.1%, and the highest frequency 50 places average altitude is only 498.9 meters. The seasonal spatial distribution difference of positive lightning is mainly caused by typical monsoon climate in china. In winter, China prevailing continental wind, dry cold air, atmosphere stable, lightning only occur in high altitude mountainous area with convective activity. Correspondingly, in summer, China is Oceanic monsoon, hot humid air, positive lightning conditions are no longer confined to the surface conditions, and depends on atmosphere activity.

The above content has been added to the manuscript (line 294-311), please review.

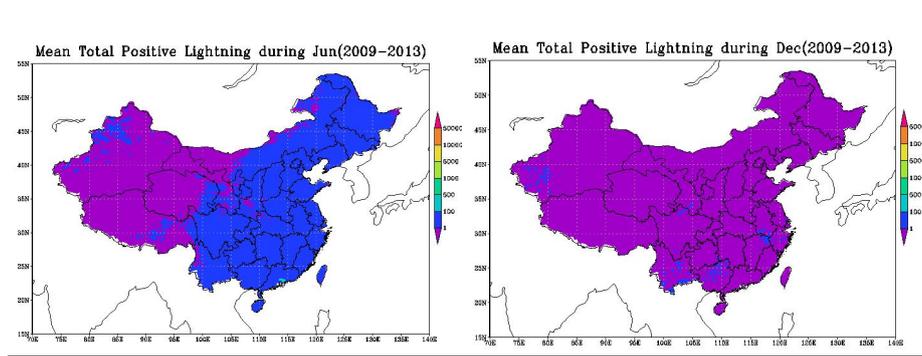


Fig.7a Positive lightning spatial distribution in Jun (left)and Dec (right)

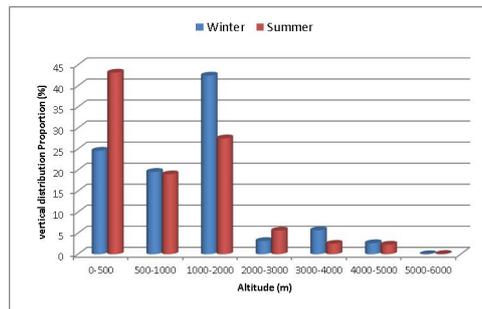


Fig7bPositive lightning vertical distribution proportion with altitude in winter and summer

Comment 4: The newly added content about lightning current is brilliant. I would like to suggest to add some description about the lightning current calculation algorithm rather than just providing a result.

PS: Thank you very much for your suggestion. Because the lightning current algorithm is also more complex, it will take too much space to describe here. The scope of this article mainly analyzes the lightning data of China, we does not want to involve more lightning detection technology. Lightning current algorithm has been published, if you are interested, the specific content can refer to reference (Ma, Q.M, 2015).

Below is an overview of the algorithms.

Lightning current formula: $I_p = SNF \cdot \overline{RNSS}$,

This is a fitting formula, used of artificial lightning and lightning positioning system synchronous observation, obtained two sets of independent observation data, and then the two sets of data fitting.

$$RNSS = SS \cdot \left(\frac{r}{100}\right)^\beta \cdot \exp\left(\frac{r-100}{\lambda}\right)$$

Among them, SNF expressed signal normalization factor.

RNSS represents normalized to 100Km signal strength, and SS represents the original electric or magnetic field signal strength., In CMA LDN ADTD lightning positioning system, β is set to 1

(assuming the only signal measured is the radiation field) , λ is set to infinity, SNF=0.392.

\overline{RNSS} is averaging the normalized signal intensity RNSS of all station.

Thanks again for the reviewer's comments and suggestion.