Real-time probing the daytime fluctuations of lower ionosphere using time domain waveform of Narrow Bipolar Events and its preliminary results

Feifan LIU[1] #, Baoyou ZHU[1] +, Ming MA[1], Changzhi PENG[1], Wenwei WANG[1]

1. *University of Science and Technology of China, China*

#*Corresponding author: lff@mail.ustc.edu.cn* +*Presenter*

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1. Introduction

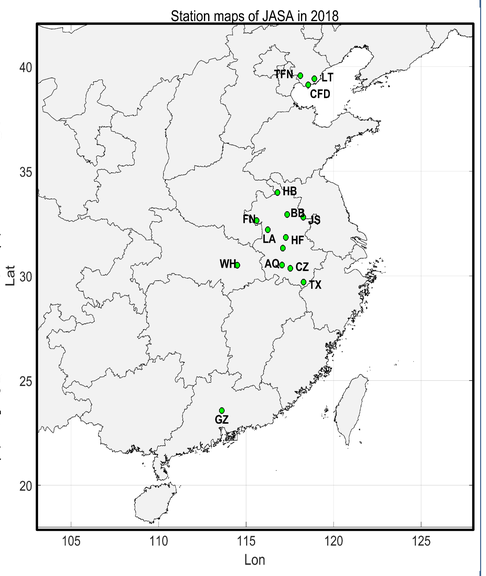
Lower ionosphere is difficult to detect as its low electron density and low altitude ranged from 60-95 km. Recently, an alternative method to study lower ionosphere is by using powerful lightning signals in very low frequency/ low frequency (VLF/LF) which propagate between lower ionosphere and ground, making its possible to estimate the D region electron density parameters along a given propagation path.

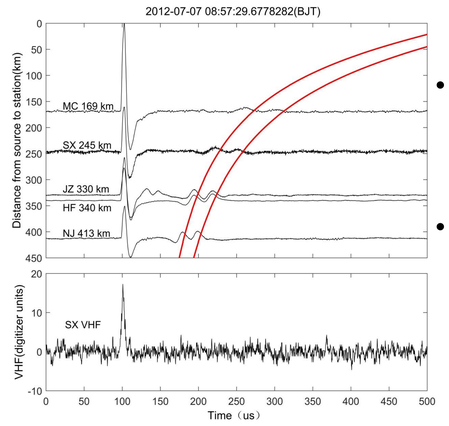
Narrow bipolar events(NBEs) is one sort of the distinguished intra-cloud discharges, which have clear reflected wave pair compared with cloud-ground (CGs) in the definitely observed distance. In this work, we investigate the daytime fluctuations of lower ionosphere by analyzing the time domain VLF/LF waveform emitted by Narrow Bipolar Events (NBEs), which were recorded by a 12-station lightning location network called Jianghuai-Area Sferic Array (JASA) for a systemic real-time monitoring of lower ionosphere. The preliminary results show that the short-time fluctuation of the lower ionosphere is significantly modulated by the solar flares and exhibit a significant asymmetry during sunrise and sunset.

2. Instrumentation and Data

The Jianghuai Area Sferic Array (JASA)

- 12 stations, GPS synchronized
- Sampling lightning signals(5 M/s) with no-dead time
- Combination of long and short baseline for monitoring broad-area lower ionosphere
- Real-time 2-D lightning location and estimation for virtual reflection height (**http://222.195.83.28:8081/**)



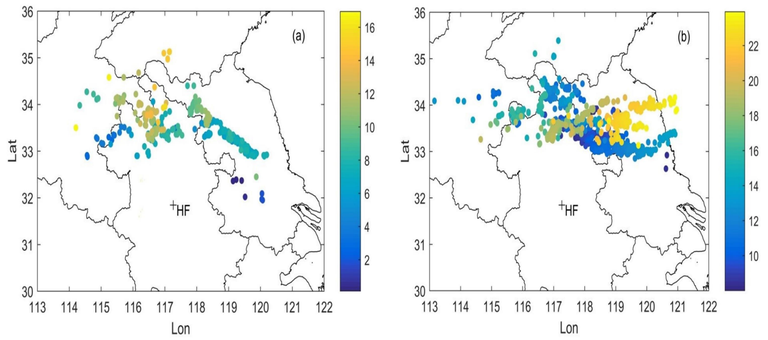


- Recorded narrow bipolar pulses and the associated with VHF radiation
- The solid red line indicates the arrival of predicted reflection waveform versus distance

3. Observations

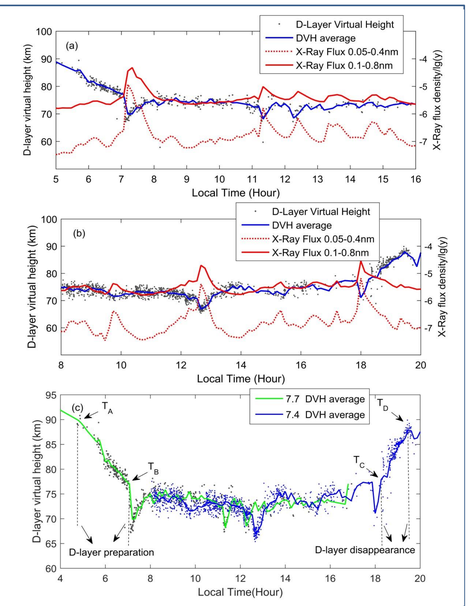
Case study

We cautiously select thunderstorm based on the criterial that produce numerous NBEs for a long time. The figure below shows the selected locations of NBE during local time 5:00-16:00 (color scale on the right) from a local thunderstorm on July 7th,2012 (a). The locations of NBE during local time 8:00-24:00 (color scale on the right) from a local thunderstorm on July 4th,2012(b).

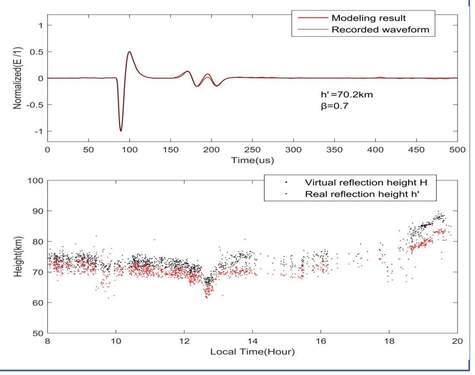


In order to further investigate the response of lower ionosphere to the solar flare, the X-ray flux density with different wavelength are used to study the correlation between them. The below figure shows that the ionosphere height has a significant fluctuations during a solar flare, and the lower ionosphere diurnal variation pattern exhibiting a significant asym metry during sunrise and sunset.

- The virtual ionosphere reflection heights retrieved from NBE and X-ray flux density on July 7th (a) and July 4th (b)
- the virtual height of D-layer decreases linearly with a rate of 5.9km/h during sunrise, while increases linearly at a rate of 8.6km/h during sunset, showing a significant asymmetry during the daytime cycle



- Comparison between the real height retrieved by D layer electron density model based on double exponential distribution(red point) and the virtual reflection height (black point)



4. Discussion

In this work, the time domain VLF/LF waveform emitted by Narrow Bipolar Events (NBEs) are analyzed to retrieve the ionosphere height, which were recorded by an 12-station lightning location network called JASA for a systemic real-time monitoring of lower ionosphere. Our results show that the diurnal variation of lower ionosphere exhibits a significant asymmetry during sunrise and sunset, indicating that electron production in the lower ionosphere is dominated by the effect of solar radiation accelerating the neutral atmospheric molecules. It is potential to monitor the lower ionosphere in real-time by JASA.