The Relationship between Fireball and HRO Long Echo

Erina Yanagida（Tohoku University）
Shinobu Amikura（University of Tsukuba）

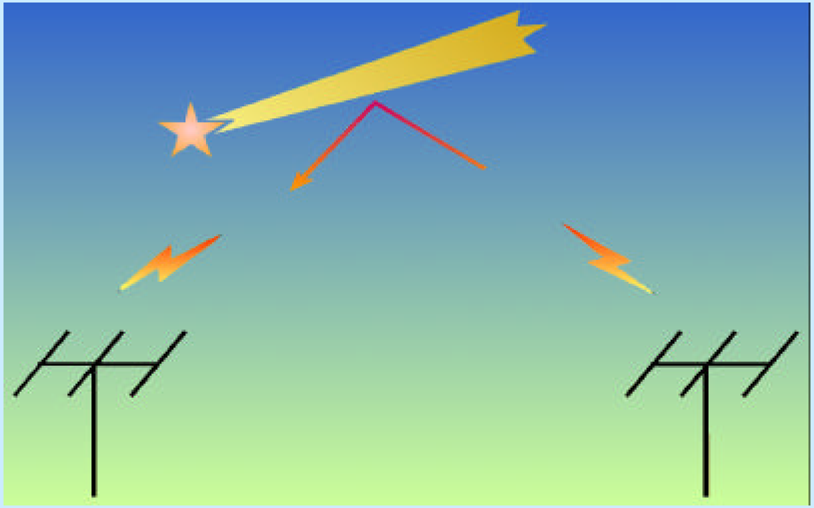
RMO (Radio Meteor Observation)

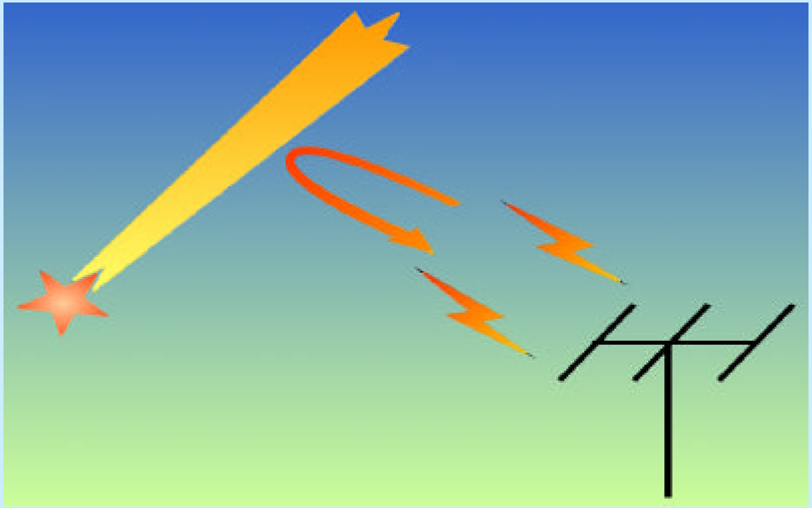
We mainly use visual observation . But that method can be no use if it is cloudy. Now, we have handy way ,which we can use whenever it is and no matter how the weather is—RMO.

We are going to explain shortly how RMO method has established. A certain transmitting stations are constantly working, and we usually cannot receive the radio wave. But when meteors come into the atmosphere, meteoroids ionize materials in the atmosphere and themselves into electrons and ions, which makes ionized trail . The spot reflect a particular radio wave. We can notice the existence of meteor by catching reflected radio wave.

In the case of RMO we call the radio wave reflected by ionized trail specially "Echo"

Radio wave reflects in two ways, forward scatter and back scatter. In Japan we take forward scatter, and in this way transmitting station and receiving station are located in different point. Rader observation comes under back scatter.





The figure at the upper left illustrates forward scatter, and at the upper right back scatter.
The range of frequency used in RMO belongs to ultra short waves. FM broadcasting, popular way around the world, uses this range(76.0~108.0MHz). RMO observers widely use FM radio wave as the method of observation and this method is called FRO. In Japan we used to take this method. But today, a lot of FM station have been set up, so we have trouble observing when we use FM radio wave. For that reason we are now receiving radio wave at 53.750MHz transmitted by Mr. Maekawa in Fukui Technical College.This way of observation Is called "HRO" (Ham-band Radio Observation).

Questions about HRO Long Echo

Long Echo:the echo that can receive longer time

Receiving Long Echo means arriving of the meteors which have high energy and can ionize the atmosphere for a long time. Those meteors remind us of brighter meteors such as fireballs. Radio wave observers also have such image.

However we can recognize only existence of meteor at a certain time when we receive radio wave. It is still unknown which type of echoes correspond to which meteors. We have assumed HRO long echoes are equivalent to fireballs. Fireball data by visual observation and HRO long echo data exist respectively. However no one have compared both data simultaneously.

We have an image the brighter meteors radiate,
the longer echoes we receive in wider area .
Can it really be true?

Motivation

We can divide questions which arose in two.

Is there any relationship between fireballs and HRO long echoes?

How bright meteors become HRO long echoes?

To solve these questions

We tried to identify fireball data by visual observation with HRO long echo data.

Goal is to estimate the point which meteor appeared from long echo.

Method

We identified following two data.

Fireball data
by visual observation
(The circular of Nippon Meteor Society)

HRO long echo data
observed at one received station
(International Radio Meteor Observation Project)

search HRO long echo data from fireball data in view of the time

examine again whether the object which is realized identification at one station can receive at the other stations

We are aimed to collect as much data of HRO long echoes at multiple stations at the same time which indicates appearance of fireball as we can.

Data

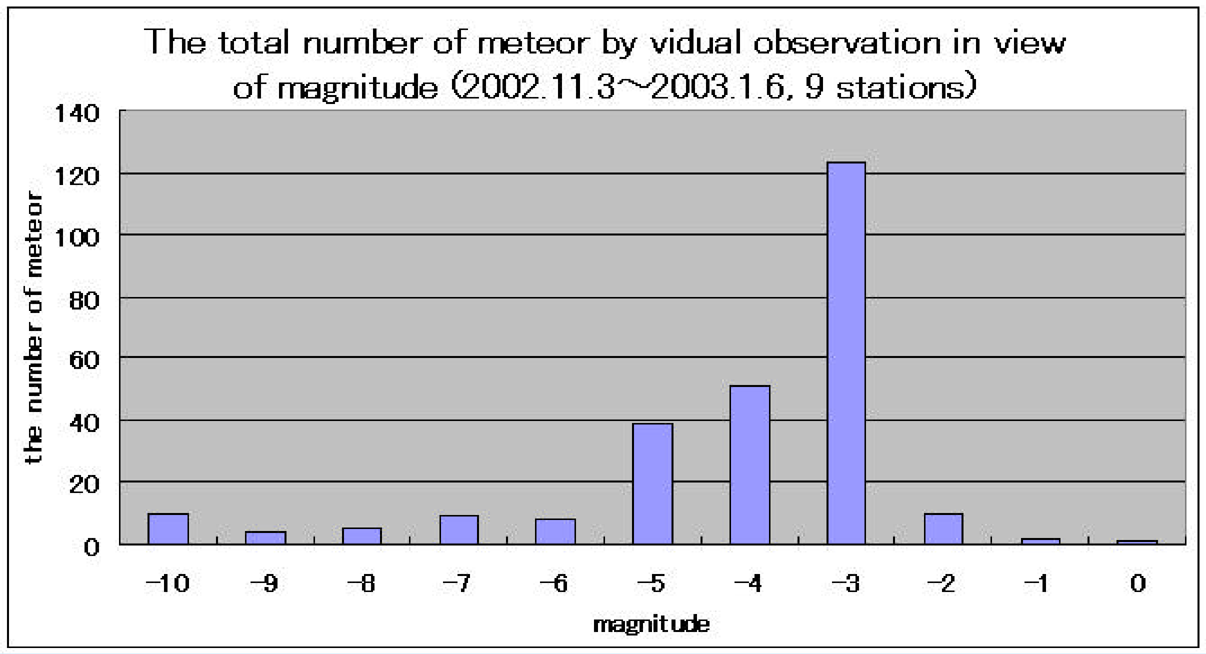
Reported data on fireballs by visual observation

(2002.11/3~2003.1/3)

HRO data at nine stations

Okayama (2002.11/3~2003.1/3)
Ibaraki(2002.11/3~11/19)
Osaka(2002.11/3~2003.1/6)
Akita(2002.11/19~12/29)
Saitama(2002.11/3~12/14)
Mie(2002.11/6~2003.1/6)
Shimane(2002.11/6~2003.1/3)
Ibaraki(2002.11/16~12/14)
Osaka@46.5MHz(2002.11/3~2003.1/6)

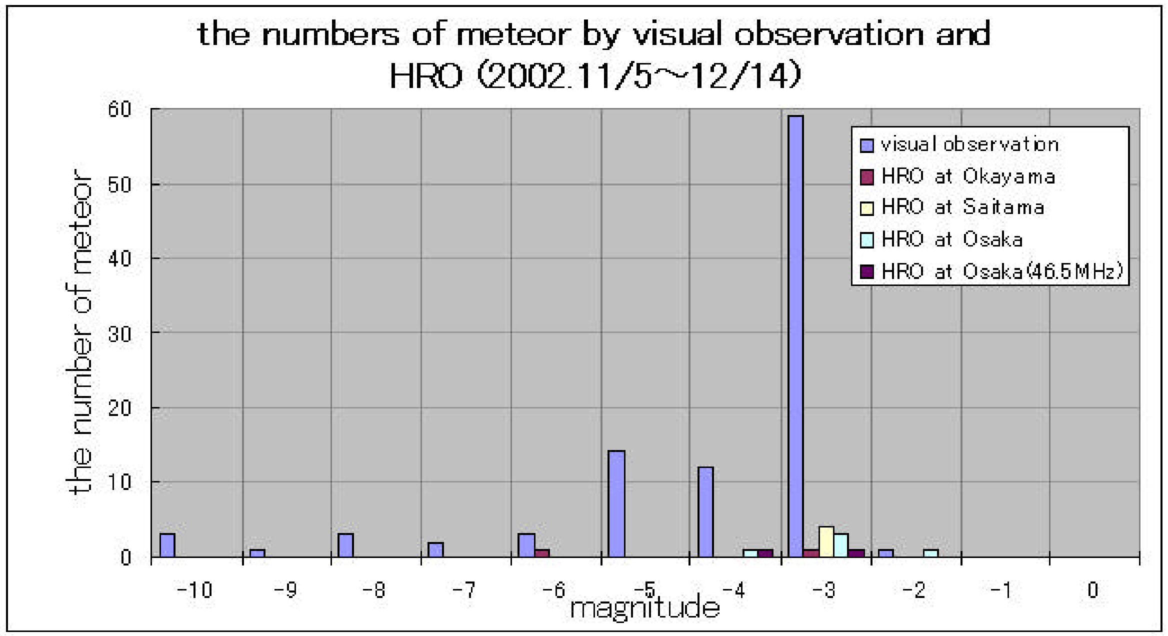
Consequences



The figure shows the total number of visual observation data used in this analysis. We summed up this data from the viewpoint of magnitude.This data is taking up the period from 2002.11.3 to 2003.1.6. at nine stations. Please note that data darker than -2mag are few because the basis this data is fireball data.

Consequence 1

The number of identification at each station by the magnitude



The upper figure is a chart we added up the number of meteor by visual observation and the number of identification by the magnitude at each stations in particular period.

This chart is characterized by a large number of identifications from -2mag to -3mag in which many fireballs are observed, although the percentage of identification at -3mag in a total of fireball data is not so high.

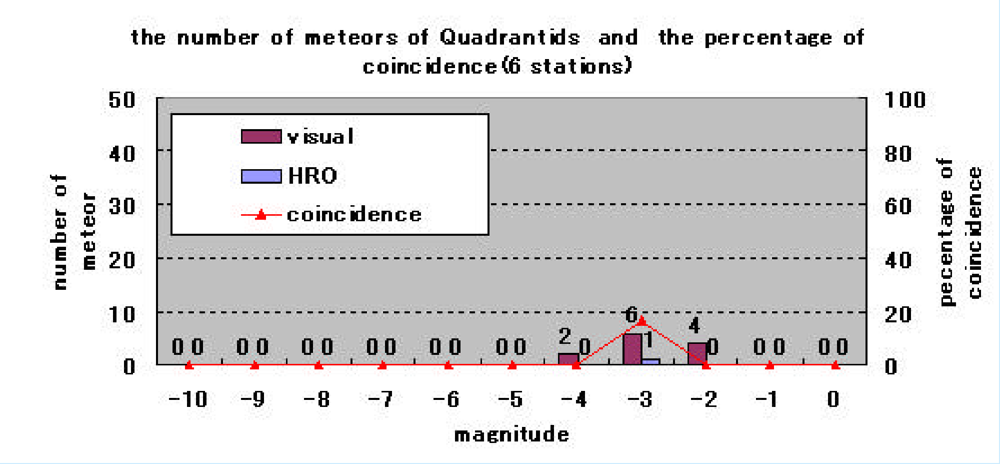
It is one of the characteristics that the number of identification is relatively large at darker magnitude.

Consequence 2

The number of fireballs by visual observation and the percentage of HRO long echo data in fireball data by the magnitude for each meteor streams

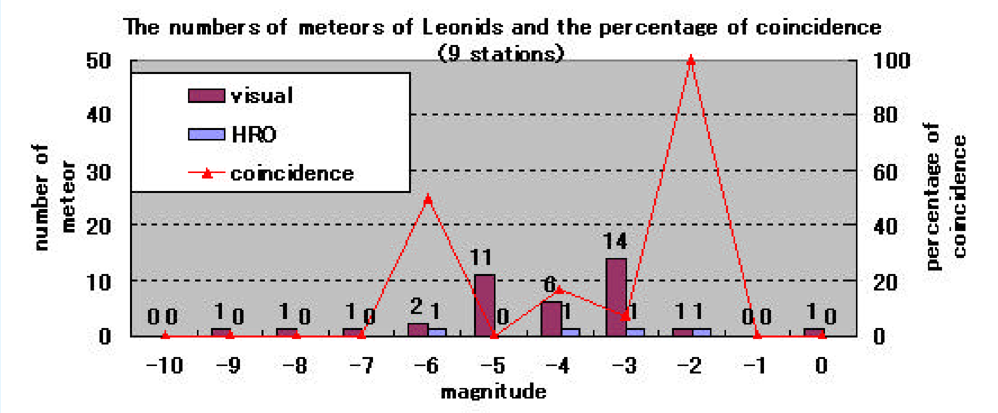
This time we summed up identification data by the magnitude in terms of meteor streams. The number of fireball data and the number of HRO long echoes is displayed in the form of a bar graph ,and the percentage of HRO long echoes in fireballs is displayed in the form of a line graph.

First we are going to show the graph of the data on Quadrantids at six stations.



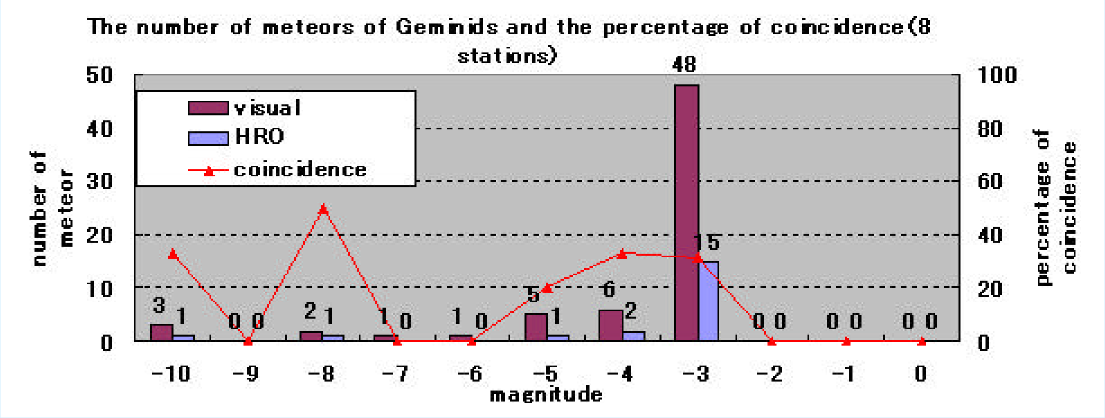
Although a population of these data is small, we tried to analyze and succeeded to identify at -3mag,which is relatively dark as a fireball.

Secondly we show the graph of data on Leonids at nine stations.



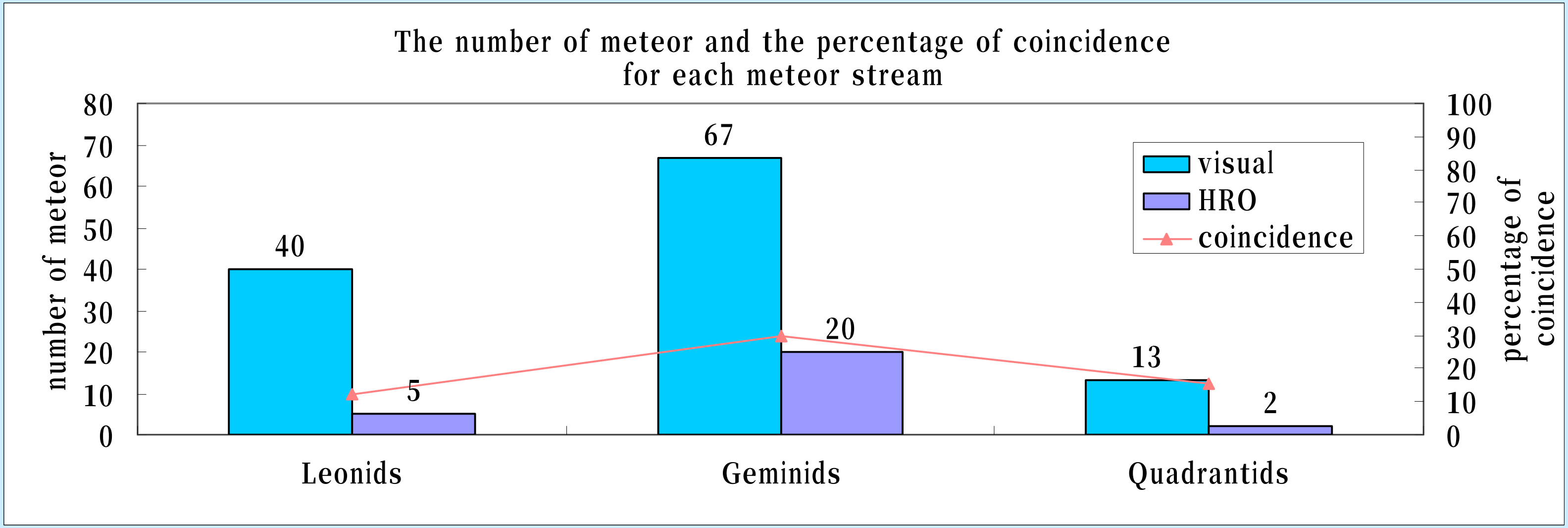
The percentages of -6mag and -2mag are high, but the problem of these data is that samples are few. On the other hand the number of samples of -4mag has enough data to say the percentage is high. Also the percentage of identification is tend to be high in darker fireball.

Following graph is about Geminids at eight stations.



In Geminids we can see high percentage of identification not only in brighter fireball such as -10mag and -8mag, but also darker fireball. And in those fireballs, percentages of -5,-4, and -3mag are similar.

We summed up the percentage of identification for each meteor streams.



The percentage is high in following order; Geminids, Quadrantids, and Leonids.

Conclusion

＊ The percentage of identification is higher in darker fireball(around -2mag to -4mag)

＊In Geminids the percentages of -5,-4,and -3mag with many samples are almost same.

＊In Geminids the percentages of -10 and -8mag are high.

＊ In Geminids the percentage is higher than other meteor streams.

＊ In Leonids the percentage of -4mag is higher than other magnitude class.

＊ The percentage is high in following order;Geminids, Quadrantids, and Leonids.

Consideration

Although samples are not enough to analyze the data, we tried to pick up points that seems important.

The relationship to magnitude

The percentage of identification is inclined to be high in darker magnitude.

Lowness in percentage s of identification

The percentage is exceedingly small; the percentages of each meteor stream less than 30%.

⇒ We cannot simply say brighter meteors are received as HRO long echo.

We think the tendency for darker fireballs to be received as HRO long echo means that there is some misunderstanding about the view HRO long echoes correspond to bright meteors.

But it must be true that high energy meteors which can maintain high density of electron bring about HRO long echoes. Bright meteors ought to have high energy. Why fireballs is not appropriate in this case?

Expected cause・・・・Limitation of observable height

In HRO the height at which we can observe is restricted by the density of the atmosphere. At the outside of that area we are unable to detect meteors because electronic is not enough. It is possible most fireballs shoot in the height at which we cannot observe.

The relationship to geocentric velocity and population index

The order of the percentage of identification(coincident) for each meteor streams is equal to that of geocentric velocity.

Leonids(72km/s)＞Quadrantids(44km/s)＞Geminids(25km/s)

And the order of population index corresponds with those relationship.

Leonids(1.9)＜Quadrantids(2.3)＜Geminids(2.5)

Population index: gradient of graph that takes magnitude as the horizontal axis and the number of meteors as the vertical axis.Smaller number of population means the meteor stream has more bright meteor.

Leonids is known as it has many bright meteors. In relation to discord with bright fireballs, why the coincidence percentage of Leonids is smallest? On the other hand the coincidence percentage of Geminids is largest although it has many dark meteors,which has low energy.

Characteristics of Geminids

The percentage of dark meteors is high. Most meteors have brightest point at the middle of the track.

Characteristics of Leonids

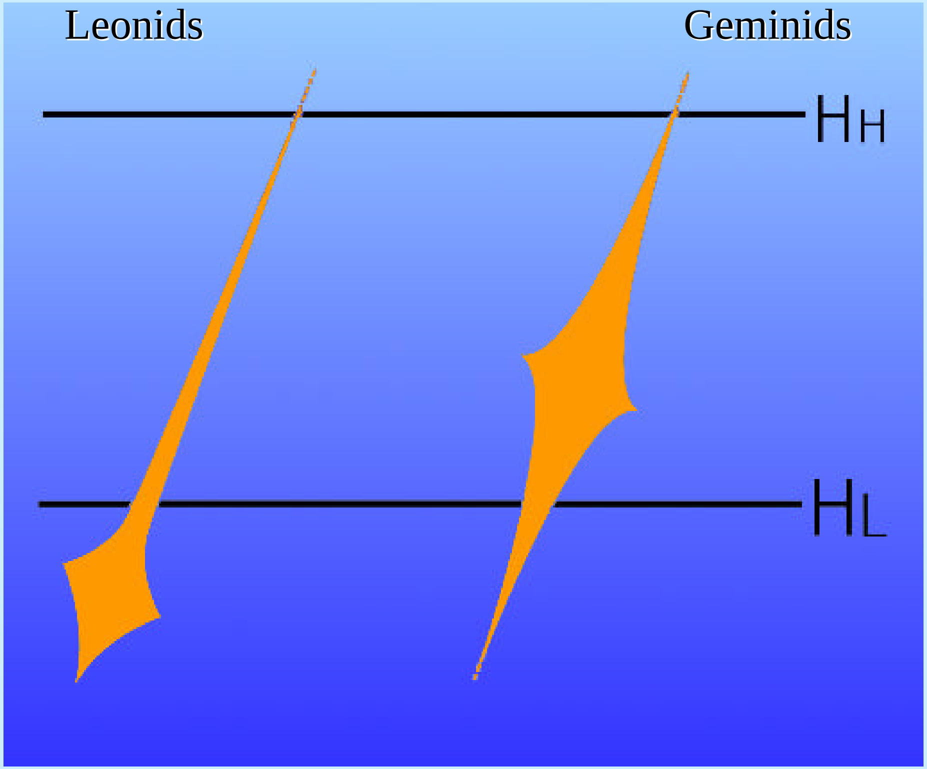
The percentage of bright meteors is high. Many meteors have brightest point at the end of the track.

The difference between two meteor streams about the way to radiate

→ The difference of height where meteors radiate the most

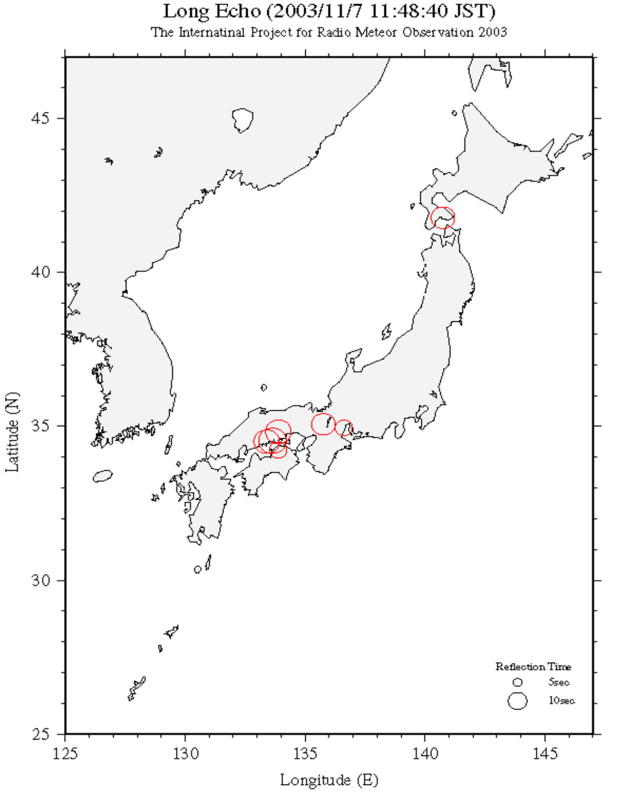
Meteors of Leonids radiate most brightly at the end of the track. On the other hand they radiate dark at the beginning of the track. Because their geocentric velocity is rapid, they radiate in wide range of height. Considering the upper dark part is in observable height, since density of the electron is not enough, there is high possibility that fireballs cannot be received as HRO long echo.

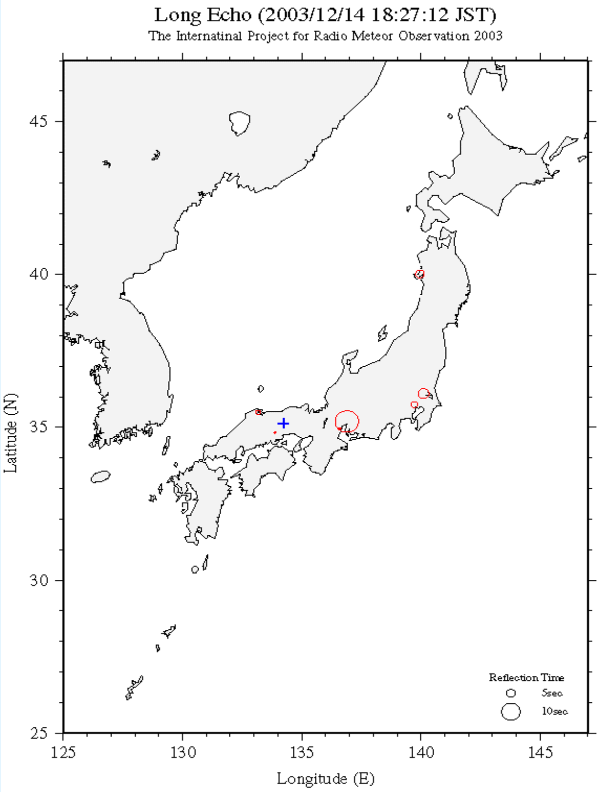
Meteors of Geminids are not so bright, and it keeps almost same brightness from starting point to end of the track. Since geocentric velocity is low, the height where meteors start to radiate is high. Compared with meteors of Leonids only in upper part, those of Geminids are brighter. In this part the density of the electron is relatively high, this state continues for a long time. Assuming that the upper part Is In observable height, it seems that meteors of Geminids is comparatively easy to observe.



The left figure shows abstractly how meteors of Leonids and Geminids radiate.The left one is for Leonids, and the right one Is for Geminids. H(High) and H(Low) respectively mean the maximum and minimum height which can be observed.
Assuming that the brightest point of both meteor streams is at the he height as we drew and only around the brightest point the density of electron don't become enough, we can explain the difference in the percentage of coincidence.

Examples of the map pointing the place a meteor radiate and length of the time we was receiving the long echo





We make distribution maps of long echo with the data of the simultaneous coincident echoes at many stations. We will be able to estimate radiating point by making many more maps.

Future work

Contrary to our expectation, the total number of coincidence was highly low. So we are attempting to analyze data in more extensive range of magnitude. Then we may possibly discover a new relation. We have expected that darker meteors than we have imagined we can easily receive as HRO long echo.

The coincident relation on meteor streams is similar to to the relation of geocentric velocity and that of population index. Then we can expect the relationship with radiating height. All things considered we will have to analyze further.

We are aiming to estimate appearing spot of fireball from the data of coincidence at plural stations