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Peak estimate of the 2001 Leonids in HRO in comparison with FRO

By

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Abstract: In Japan, there are mainly two methods of Radio Meteor Observation, FM-band and Ham-band Radio Observation (FRO and HRO). In 2001, so many Leonid meteor echoes appeared with both methods that it became impossible for one echo to be separated from the others in HRO method because of saturation effects, though these echoes in FRO could be separated. The lower frequency of the HRO radio waves caused this saturation. This research is to estimate the number of HRO echoes during the saturation period around the Leonid peak by comparing HRO with FRO. In this paper, to estimate the number of the echoes at the peak time, a useful new index named "FRO/HRO ratio" is defined, which shows the ratio of the echo numbers in FRO to HRO. As the result, the number of HRO echoes at the Leonids' peak time in 2001 was successfully estimated, and its profile during saturation in HRO became clear. Additional analysis for the 2001 Geminids in the same way, and its comparison with that of Leonids, make it possible to find some relative characteristics of these meteor showers such as the geocentric velocity, the beginning and end heights of the meteors, and so on.
Consequently, the FRO/HRO ratio can make the saturated data usable and also reveal some other aspects of meteor showers.

1. INTRODUCTION

When a meteoroid comes into the atmosphere, it ionizes the air around it. This ionized area reflects high-frequency radio waves which usually go through the ionosphere. The reflected radio waves show that there was a meteor at the detection time. In Radio Meteor Observation (RMO), the observers receive these reflected radio waves and count how many times they receive the reflected waves per hour, that is, the number of the meteor echoes in Hourly Rate (HR) is obtained.

In Japan there are mainly two methods of RMO. One is FM-band Radio Observation (FRO) using broadcasting radio waves in FM-band. Although the FRO was the major method until only a decade ago, another RMO method, Ham-band Radio Observation (HRO) has recently been spread out and now the HRO is the major one among Japanese meteor observers. The biggest reason of this change (from FRO to HRO) was the increase of interference in FRO due

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to the recent rapid increase of FM-band broadcasting stations all over the country. In Japan, most HRO observers receive 53.750 MHz waves transmitted by K. Maegawa. The transmitting station is located in Fukui, Japan. The frequency of HRO is a little lower than that of FRO (76.0–108.0 MHz).

In 2001, Japanese observers encountered the Leonids meteor storm. Around the Leonids peak (18:00UT on Nov.18), the echo diagram of HRO was affected by the saturated with its long echoes, so that became impossible to separate one echo to the other, however, the FRO was not saturate so much. Therefore, the first purpose of this research is to estimate the number of HRO echoes around the peak time. After being established this estimation, the Leonids activity in 2001 can be compared with the previous Leonids activities for example in 1998 (K.Suzuki (1998)), which was nearly saturated with the meteor echoes themselves and whose number of HRO echoes around the peak time in HR is uncountable and not estimated by FRO. The second purpose is to reveal the relationship and the difference between FRO and HRO due to difference of these frequency brings about.

2. OBSERVING STATIONS

For more accurate comparison between HRO and FRO, a couple of data that have the same or quite similar baseline of both HRO and FRO should be chosen. The baseline here means the angle formed by the line between the Transmitting and Receiving stations and the equator circle. The map in Fig. 1 shows observing stations. The transmitting station is indicated by T, and the receiving stations are shown by R.

An FRO data which has a certain baseline should be paired with the corresponding HRO

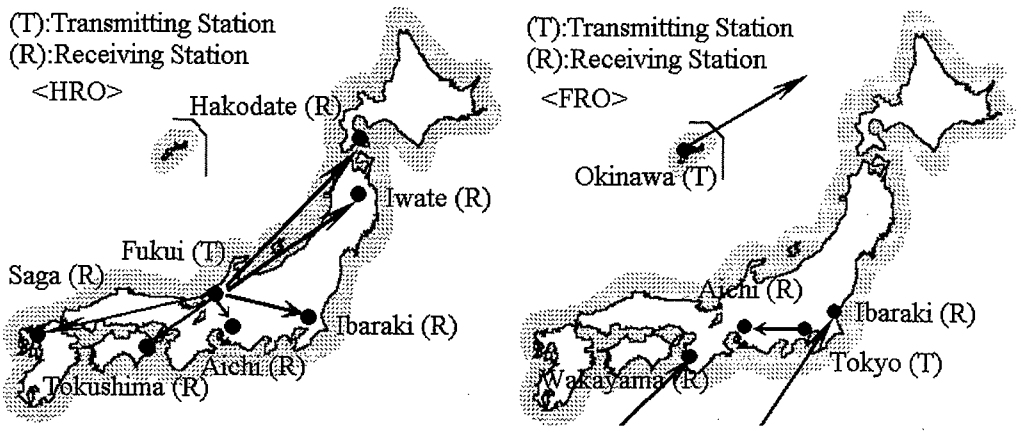

Fig. 1: The map of observing stations

result whose baseline is the same as or quite similar to the former one.

In this research, six HRO data and three FRO data were collected. All of these HRO observers used the same transmitting station at Fukui National College of Technology (Fukui, Japan).The information about observational method at each observing station is shown in the following table (table 1).

Table 1: A list of observing stations. All of the HRO data are picked out from the database of radio meteor observation (H.Ogawa (2001)) and each FRO data is provided by each observer.

Site	Method	Transmitter	Frequency	Observer
Hakodate	HRO	Fukui-NCT	53.750 MHz	Iai-girl Junior and Senior HS
Iwate	HRO	Fukui-NCT	53.750 MHz	Masayuki YAMAMOTO
Ibaraki	HRO	Fukui-NCT	53.750 MHz	University of Tsukuba
Aichi	HRO	Fukui-NCT	53.750 MHz	Asahigaoka HS Astronomy Club
Tokushima	HRO	Fukui-NCT	53.750 MHz	Awa HS Amateur Radio Club
Saga	HRO	Fukui-NCT	53.750 MHz	Taisuke KONDO
Ibaraki	FRO	FEN Okinawa	89.0 MHz	Ibaraki-NCT Radio Club
Aichi	FRO	FM Tokyo	80.0 MHz	Yoshinori YAMAMOTO
Wakayama	FRO	FEN Okinawa	89.0 MHz	Misato Observatory

3. THE NEW INDEX, "F/H RATIO"

There have been no suitable way to estimate the number of HRO echoes from that of FRO echoes. Therefore, in order to reveal the relationship between HRO and FRO, a new index "FRO/HRO ratio" (hereafter "F/H ratio") which permits to estimate the number of HRO echoes and to make the Leonids activity in HRO clear is newly defined in this research.

3.1 The definition "F/H ratio"

The new index, $FRO/HRO\,ratio$ is defined as the following formula:

$$FRO/HRO\,ratio \;=\; \frac{N_{FRO}}{N_{HRO}} \tag{1}$$

where the N_{FRO} is the number of the FRO echoes in Hourly Rate (HR), and similarly, the N_{HRO} is the HR number of HRO echoes. Then, the following formula is derived from the equation (1).

$$E_{HRO} \;=\; \frac{N_{FRO}}{F/H\;ratio} \tag{2}$$

where E_{HRO} means "HRO-Expectation", i.e., the expected value of HRO echoes. These formulas clear up the Leonids activity during the saturating period of HRO.

To calculate the HRO-Expectation, the F/H ratio is demanded to be accurate. In fact, to obtain the more accurate the F/H ratio needs more number of observed data (not limited only to Leonids), although there are not enough so far. Therefore, in this paper, the value of F/H ratio calculated from HRO and FRO data on November 17th in 2001 (UT) is treated as its standard. On that day there was weak Leonids activity in Japan.

3.2 The Reliability of "F/H ratio"

In this research, three comparisons of the echo counts in the 2001 Leonids were made: a comparison between Aichi(FRO) and Saga(HRO), between Aichi(FRO) and Ibaraki(HRO), and between Aichi(FRO) and Aichi(HRO). And also two comparisons about the activity in the 2001 Geminids, which is also one of major meteor showers, were made: a comparison between

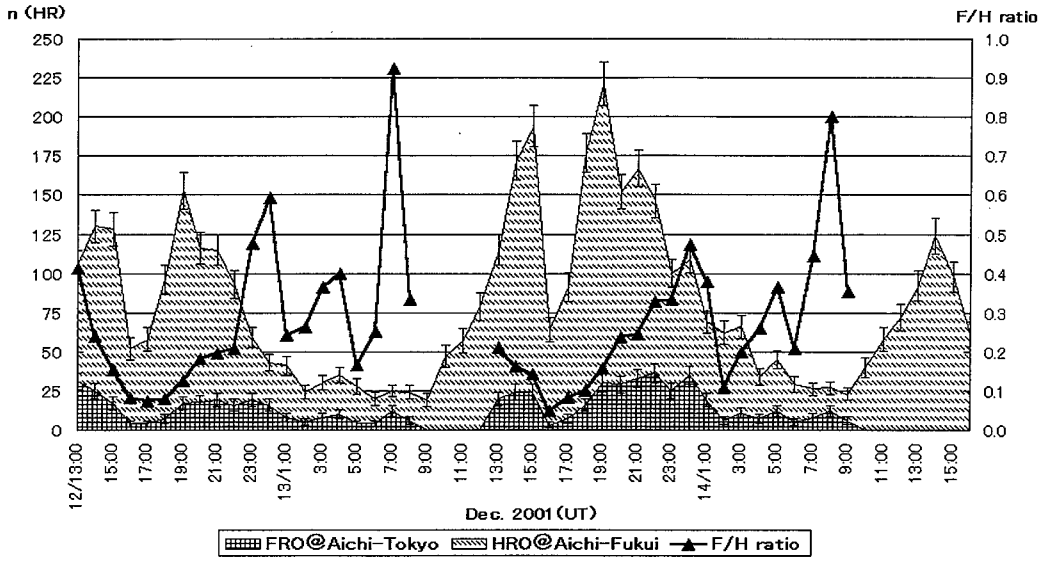

Fig. 2: The comparison of the echo counts in the 2001 Geminids under the condition of the different baselines condition — Aichi(FRO) and Aichi(HRO)

Aichi(FRO) and Saga(HRO) and between Aichi(FRO) and Aichi(HRO). Figures 2 and 3 show the latter two comparisons about the 2001 Geminids. The compared data shown in the first case was detected in the condition of different (opposite) baselines (Fig. 2), and the second data was obtained by two observations with almost the same baselines (Fig. 3).

These graphs show that the shape of the graph of F/H ratio is almost the same every day around the peak time of a certain meteor shower whether the baselines are the same or not. Thus, as these graphs shows, the F/H ratio is not so sensitive to the active level of the meteor showers, and it is proved to be an useful index to estimate the number of HRO echoes from that of FRO echoes.

4. RESULTS

The results of HRO and FRO of the 2001 Leonids are shown in Figure 4. The big lack of HRO data around the Leonids peak time is caused by the saturation, and the lack in the afternoon on November 19th (UT) is by the interference.

This graph shows the results of HRO and FRO, and the calculated value of E_{HRO} (aforesaid "HRO-Expectation", see formula (2)).According to this result in Fig. 4, the curve of observed-HRO and expected-HRO curve coincided well in each other while the HRO data was not saturated or not in interference. Therefore, the expected-HRO curve gives almost the real activity in HRO: the number of the HRO-Expectation and its peak time are regarded to be what should be observed by HRO.

The estimated number of Leonids 2001 in HRO was about HR=430 at the peak time. This was extraordinary activity in HRO. Even the peak of Geminids the value was about HR=100 at these HRO stations. Comparing with recent Leonids activity or other meteor showers, the activity of Leonids 2001 is also proved to be much higher.

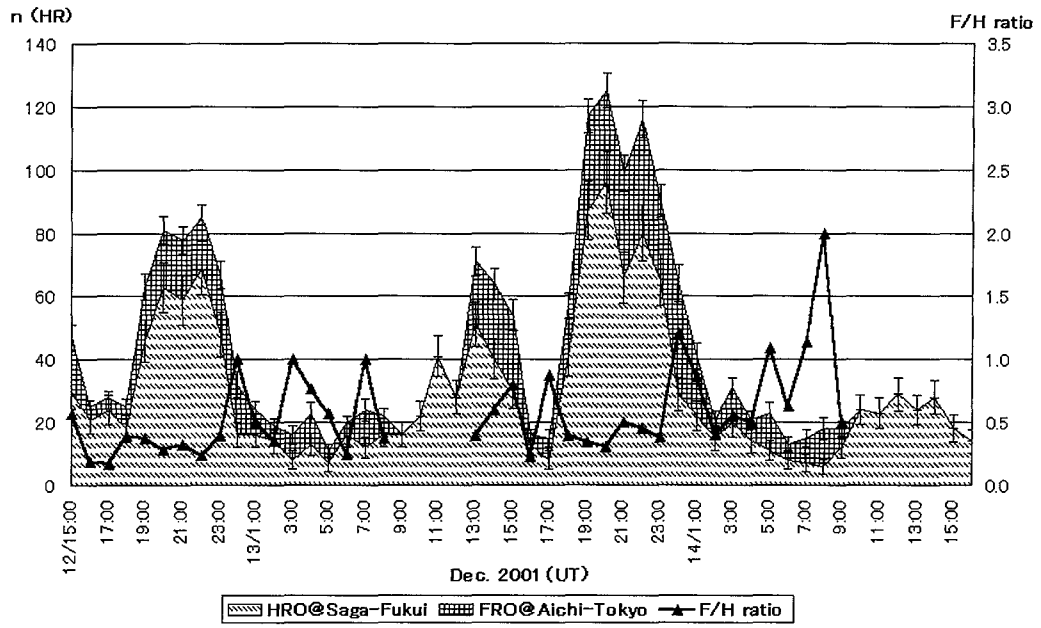

Fig. 3: The comparison of the echo counts in the 2001 Geminids under the condition of the similar baselines — Aichi(FRO) and Saga(HRO)

5. DISCUSSION

In this research, the F/H ratio plays a very important role not only in estimating the number of HRO echoes but also in providing some other information about meteor streams. One aspect of the information is the average brightness of whole the meteor stream. Bright meteors begin to produce light higher in the sky (over 100km height) and disappear at lower altitude than or at least as low as dark meteors (around 80km height). Bright meteors are generally heavier or their geocentric velocities are higher than the other normal meteors. Namely, the bright meteors have higher energy, so that these meteors ionize the air around them very much: the density of plasma there suddenly rises at the moment and makes "plasma tube" which can reflect radio waves of high frequency. The density of the plasma tube is influenced not only by the energy of the meteoroid but also by the density of the atmosphere at its height. That's why, the plasma tubes made by smaller meteoroids are always located at higher sky and their lengths are always short. And the electron density of the plasma tube made by smaller one is lower because the density of the atmosphere at the concerning altitude itself is lower. On the other hand, bigger meteoroids ablate from high sky to lower sky, so the lengths of these plasma tubes are longer and the densities of them are quite higher. These plasma tubes of latter type can reflect wider band radio waves than former type, because the latters can reflect higher frequency radio waves, which has the higher energy. Therefore, the bigger meteors can be observed by both HRO (the lower frequency) and FRO (the higher frequency), and the smaller meteors can be observed only by HRO. Considering this, conversely, FRO is seeing only lower sky or observing the brighter, bigger, and faster meteors, and HRO is seeing higher sky as well as low sky or observing the darker, smaller, and slower meteors. In other words, the value of the F/H ratio shows the rate of the bright meteors to all the meteors in these two

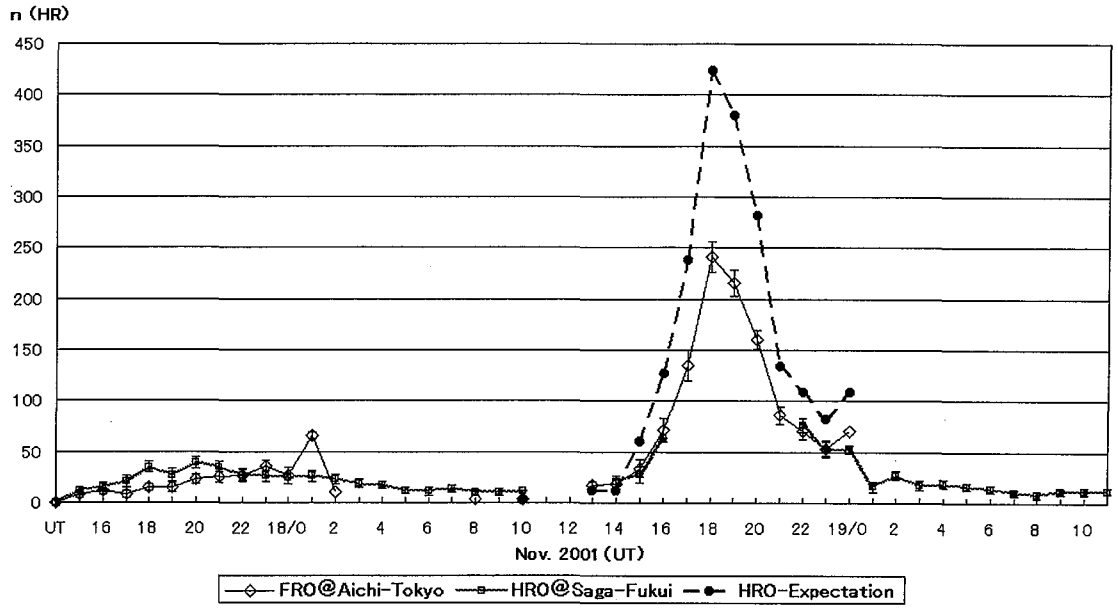

Fig. 4: The result of HRO and FRO, and HRO-Expectation of the 2001 Leonids

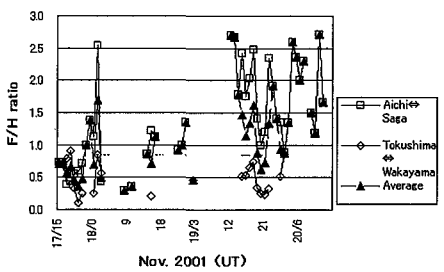

Fig. 5: The F/H ratio of the 2001 Leonids

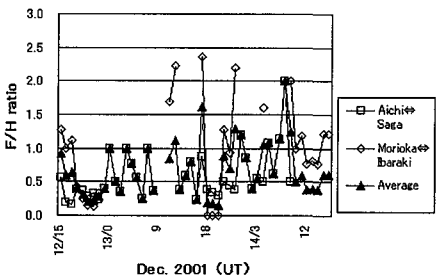

Fig. 6: The F/H ratio of the 2001 Geminids

RMO methods. This principle can be regarded to apply among the results of various meteor showers.

Figures 5 and 6 are the comparison of the F/H ratio between the 2001 Leonids and the 2001 Geminids.

The F/H ratio of the 2001 Leonids is higher than that of the 2001 Geminids. The meteors of the 2001 Leonids are regarded to be brighter and faster or heavier than those of the 2001 Geminids, and this expectation is almost the same as the previously confirmed results. Thus, considering the F/H ratio provides some relative characters such as the geocentric velocity, the biginning and end height, and the mass of one meteor stream to the others. Thus, the F/H ratio has many and more possibilities and great usefulness for investigating the characteristics of the meteors and plays an important role in getting the meteor activities.

6. CONCLUSION

Though the result of HR=430 is extraordinarily higher value, it seems that the expected-HRO curve shows almost the real HRO activity. Therefore, as a substitute for the saturated HRO data, the HRO-Expectation estimated from the number of FRO echoes using the F/H ratio can be used for the consideration of the meteor activity. In addition, this estimating method is also effective in other meteor showers (see Figs. 2 and 3).

Despite the fact that the FRO is still a very useful observation, the number of FRO observers in Japan is now surely decreasing. This research needs more FRO stations and more FRO data observed over much longer spans, especially the existence of more RMO stations in both method (HRO and FRO) almost every day is very desirable. With enough HRO and FRO data in the future, further quantitative comparisons between different showers should be possible.

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