Meteor observations of forward-scattered FM-radio echo in Busan (Korea)

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The detection system of forward-scattered FM-radio signals has been newly set up in Korea Science Academy of KAIST in Busan, Korea. The meteor observations using a 2.5m-long Yagi antenna have been carried out since May, 2015. The radio station we use is the NHK broadcasting station (85.20MHz) located in Hokkaido, Japan which is approximately 1,400 km away from Busan and is well below the local horizon. The detection is successfully running, and we examine the observed data reliability by simply checking long-lasting echoes. An additional observing station is being installed in the nearby city of Ulsan to make a cross-check. We analyze the results to find the diurnal and daily variation of the meteor rates. We are planning to pursue long-term observations in order to educate students.

1 Introduction

A forward-scattered FM broadcast radio station has been used to detect echoes when reflection of radio signals occurs from ionized meteor trails. In our country, a detection system of FM-radio echoes was introduced during the *49th National Youth Science Fair* for which an analog to digital signal converter was developed (Kim et al., 2003).

We installed the system composed of a Yagi-antenna and a commercial radio receiver. The detection software we used is the HROFFT program developed by Kazuhiko Ohkawa (Maegawa, 1999; Noguchi and Yamamoto, 2003). Successful detection is presented in this paper and any noise sources are examined. The main long-term objective is to obtain a mass distribution index in order to understand orbital behavior and activity of the parent comets.

2 Observation and data

Hardware

We use a 5-element Yagi beam antenna, a commercial radio receiver and a computer (notebook running under Windows XP) and the observing site is located on the roof of the Chang-Jo-Gwan building in our school, Busan (129.03° E, 35.17° N). The antenna is directed toward Japan in order to receive the Hokkaido NHK-FM radio transmissions at a frequency of 85.2 MHz (141.3517° E, 43.0597° N). The distance is about 1363km. Selection criteria for the radio station are addressed as follow: 1) the distance between the observing location and the transmitter has to be between 300 and 2000 km, where the reflected signals can be received by a distant antenna due to the curvature of the Earth, 2) the transmitter has to be on air 24 hours a day.

Software

We use the HROFFT(1.0.0.f) program to register echoes and we developed some Python code to count the number of meteors without any over estimation due to adjacent echoes. In the preparation to observe with the HROFFT program, the signal is set up under 10 and the signal level at 50. The signal means the sound volume of radio and the signal level indicates amplifying received power. When the level is over the 10dB threshold, then the signal is counted as a meteor echo. It can be noted that two or more adjacent counting might not be distinct detections, but possibly single echo from 'one' meteor trail. We have assumed one meteor detection within 3 seconds empirically (i.e. 3 pixels in HROFFT). As an example, the first two detections at around 2:47am in *Figure 1* are counted as one detection.

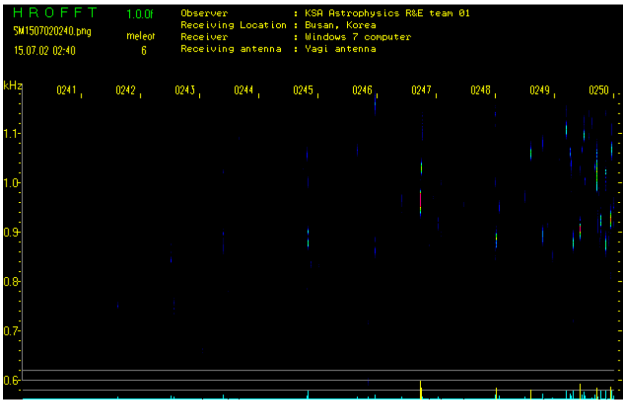

Figure 1 – Example of HROFFT Data.

Data

Observations have been carried out from 26th May to 15th August 2015 and we present observations on 80 days (data missing for 28 hours in the 9th to 10th Aug. period due to interruption from an irrelevant Windows software). Observations cover Southern Delta Aquariids and Perseid meteor showers peaking on 29th July and 12th Augustus, 2015 respectively.

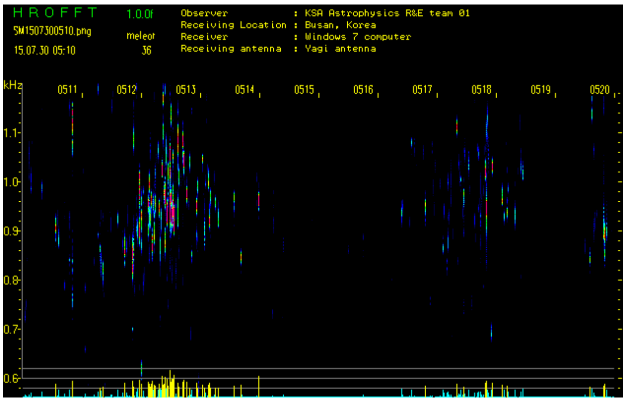

Figure 2 – HROFFT Data shown of long-lasting echoes.

Some of the HROFFT images present long-lasting echoes shown in *Figure 2*. We are not sure it is due to meteor trails or not. It is simply examined whether the signal is coming from random noise radiated by domestic electronic devices.

3 Results

Average diurnal variations on 80 days are shown on *Figure 3*. The maximum echo rate was detected between $03^{h}00^{m}$ to $05^{h}00^{m}$ and the minimum rate between $11^{h}00^{m}$ to $13^{h}00^{m}$ local time. The pattern of diurnal variations is similar to the yearly mean diurnal variation of meteor rates recorded in 2006 (Okamoto and Maegawa, 2008). However, the maximum and minimum echo rates are slightly different from the ones detected at $06^{h}00^{m}$ and $18^{h}00^{m}$ local time, respectively.

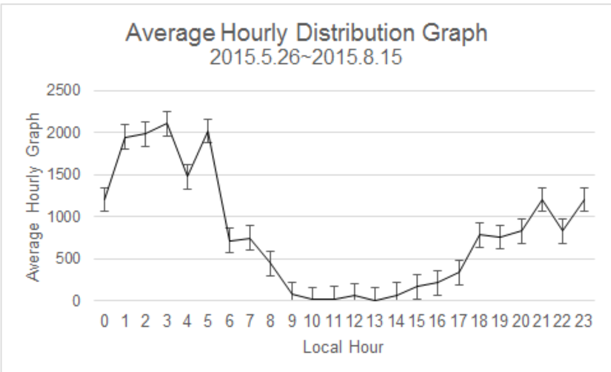

Figure 3 – Average diurnal echoes.

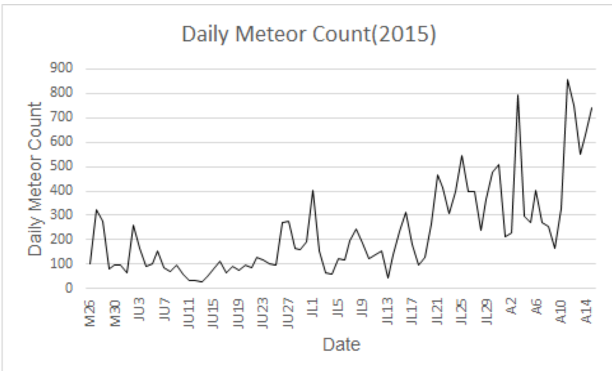

Figure 4 – Daily echoes.

Daily meteor rates are presented in *Figure 4* in order to examine possible detection of meteor showers with our new system in addition to the activities of sporadic meteors. It shows an increase of echo rates around known meteor showers of Southern Delta Aquariids (peaking on 29th Jul.) and Perseids (12th Aug.). It can be said that possible activities of meteor showers are detected in this system.

Test for source of long-lasting echoes

It is not sure whether the long-lasting echoes shown in *Figure 2* are attributable to meteor activities or random noise obtained from local electronic devices or non-meteor signals coming from sky. Various domestic noises have been generated on purpose and the corresponding HROFFT data are shown in *Figure 5*. Any of notable long-lasting echoes are not detected. Further examination is required for these unidentified long-lasting echoes.

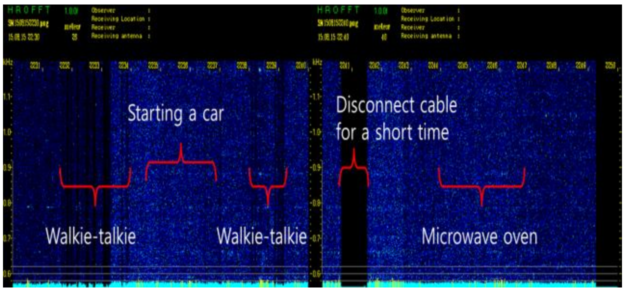

Figure 5 – Testing of any possible noises on receiving system.

4 Summary

We have recently installed our detection system for forward-scattered FM radio echoes and we run observations for 80 days from May to August, 2015. Average diurnal variation and daily variation of echoes are presented and they look similar to the pattern of meteor activities. However, the source of long-lasting echoes is unclear whether it is due to meteors or not.

In order to set up a reliable detection system, we are going to examine further the receiver set-up. It is planned to test the receiver section with an additional radio and computer connected to the same antenna. Another antenna and receiving system will be installed in Ulsan and double-checked for echoes.

Acknowledgment

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The author, *In-Ok Song*, at the 2015 IMC in Mistelbach (Photo by *Axel Haas*).

Some of the authors during the group photo: on the second row from left to right *In-Ok Song, Kyoung-Mo Kim, Mingyu Cho* and *Jinyoung Hong*, on the first row we see *Sergei Schmalz, Stane Slavec* and *Ivanka Slavec* (Photo by *Axel Haas*).