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The Radio Meteor Zoo: searching for meteors in BRAMS radio observations

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Abstract

The Radio Meteor Zoo is a citizen science project where users are asked to identify meteor echoes in BRAMS radio data obtained mostly during meteor showers. The project will be described in details and preliminary results obtained during the Perseids and Geminids 2016, Quadrantids 2016 and 2017, and Lyrids 2017 will be presented.

1. Introduction

BRAMS (Belgian RAdio Meteor Stations) is a Belgian radio network using forward scattering of radio waves to detect and study meteoroids falling in the Earth's atmosphere. The network comprises a dedicated beacon transmitting a continuous sin wave with a frequency of 49.97 MHz and a power of 150 watts. 30 receiving stations are spread all over the Belgian territory.

BRAMS data are saved every 5 minutes as an audio WAV file. They are usually presented as spectrograms which span 200 Hz and are centered on the direct signal coming from the beacon. An example of spectrogram including underdense and overdense meteor echoes is shown in Figure 1.

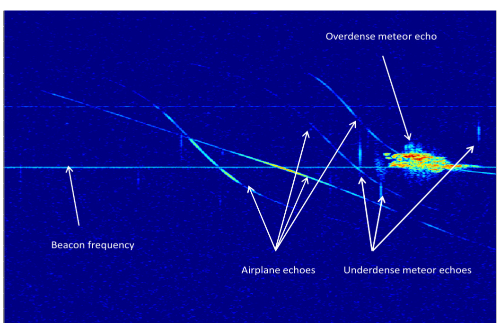

Figure 1: example of a BRAMS spectrogram

Every day more than 8000 WAV files are generated via the BRAMS network and contain thousands of meteor echoes. Therefore automatic detection methods of meteor echoes must be used. Two methods have been developed by the BRAMS team. They work fairly well for underdense meteor echoes but are always complicated by the presence of airplane echoes and/or local noise. In order to assess the quality of these algorithms, we need to estimate the true positive and true negative rates provided by each method. For that purpose, manual counts are used based on an in-house tool developed to draw rectangles around meteor echoes in spectrograms.

Another difficulty comes from the overdense meteor echoes which can display very complex and varied forms in spectrograms. During meteor showers a lot of these overdense echoes are observed and therefore the reliability of automatic detection algorithms is questionable. An example is provided in Figure 2 obtained during the Perseids 2016. In this case the human eye stays the best detector.

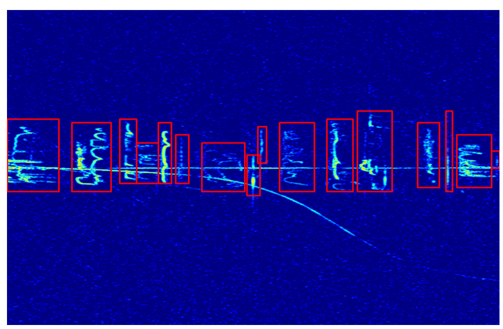

Figure 2: an example of a BRAMS spectrogram obtained on August 12 during the Perseids 2016. The red rectangles are manual detections of meteor echoes.

2. The Radio Meteor Zoo

In summer 2016, the BRAMS team launched the citizen science project “The Radio Meteor Zoo” (www.radiometeorzoo.eu) in collaboration with people at Zooniverse (www.zooniverse.org). The idea is to ask citizen scientists to inspect the BRAMS spectrograms obtained during meteor showers and draw rectangles around meteor echoes. A tutorial has been provided to briefly teach the user on what is a spectrogram, what are the various signals that can be seen in it and how to differentiate a meteor echo from other signals. So far, more than 22000 images have been analyzed and about 4600 users have registered. The Radio Meteor Zoo (RMZ) website will be presented in details during the talk.

In order to be able to analyze the RMZ contributions, we must be able to answer the following important questions: 1) what is the minimum number of volunteers needed to inspect a given spectrogram? 2) in a given spectrogram, how can we accurately derive the number and position of meteor echoes based on individual contributions? For that, a small-scale test was made with 12 spectrograms and about 35 test-users allowing us to decide that each spectrogram should be inspected by 10 users and that a given pixel on the image should be considered as being part of a meteor echo if it is included in at least 4 rectangles drawn by different users. In that way, we minimize the number of false positive and false negative rates without the need of requesting too many identifications. Individual connected pixels are then included in a potential meteor echo by drawing the largest rectangle including them.

3. Preliminary results

Figure 3 shows an example of a spectrogram inspected by 10 users (red rectangles) and the selected potential meteor echoes based on the method described above. As can be seen most meteor echoes are detected correctly although sometimes two meteor echoes close to each other are included in a single detection.

BRAMS data from the Perseids and Geminids 2016, Quadrantids 2016 and 2017, and Lyrids 2017 have been analyzed by RMZ users. The results will be presented. An example of results is given in Figure 4. It is the activity curve of the Perseids 2016 constructed by using only meteor echoes with a duration longer than 10 seconds (overdense meteor echoes).

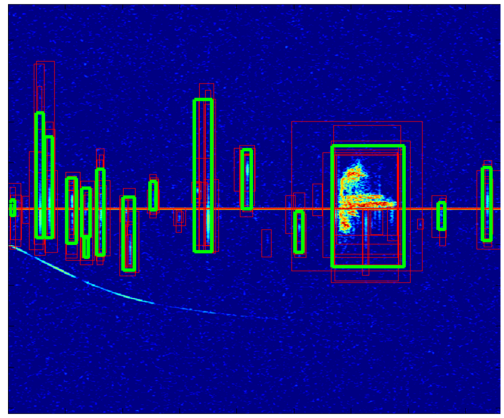

Figure 3: example of a spectrogram inspected by 10 Radio Meteor Zoo users (red rectangles). The green rectangles are aggregated rectangles and correspond to the meteor echoes detections.

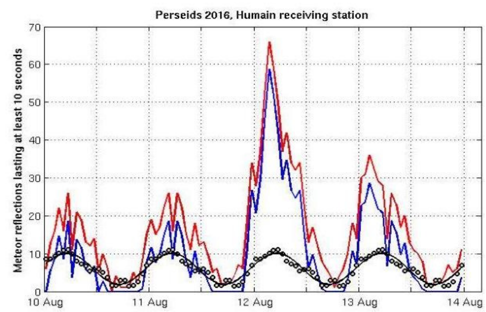

Figure 4: Activity curve of the Perseids 2016 using results from the RMZ users and meteor echoes lasting more than 10 seconds. Red curve is total activity, black dots are background activity (with a sine fit) and the blue curve is the estimated raw activity from the Perseids only.

4. Summary and Conclusions

The RMZ proves to be extremely popular and works fairly well. Preliminary results will be shown and planned improvements will be discussed.